

version may be used. Conformity analyses for which the analysis was begun during the grace period or no more than 3 years before the FEDERAL REGISTER notice of availability of the latest emission model may continue to use the previous version of the model specified by EPA.

(2) For non-motor vehicle sources, including stationary and area source emissions, the latest emission factors specified by EPA in the “Compilation of Air Pollutant Emission Factors (AP-42)”¹ must be used for the conformity analysis unless more accurate emission data are available, such as actual stack test data from stationary sources which are part of the conformity analysis.

(c) The air quality modeling analyses required under this subpart must be based on the applicable air quality models, data bases, and other requirements specified in the most recent version of the “Guideline on Air Quality Models (Revised)” (1986), including supplements (EPA publication no. 450/2-78-027R)², unless:

(1) The guideline techniques are inappropriate, in which case the model may be modified or another model substituted on a case-by-case basis or, where appropriate, on a generic basis for a specific Federal agency program; and

(2) Written approval of the EPA Regional Administrator is obtained for any modification or substitution.

(d) The analyses required under this subpart, except § 51.858(a)(1), must be based on the total of direct and indirect emissions from the action and must reflect emission scenarios that are expected to occur under each of the following cases:

(1) The Act mandated attainment year or, if applicable, the farthest year for which emissions are projected in the maintenance plan;

(2) The year during which the total of direct and indirect emissions from the action is expected to be the greatest on an annual basis; and

(3) any year for which the applicable SIP specifies an emissions budget.

¹Copies may be obtained from the Technical Support Division of OAQPS, EPA, MD-14, Research Triangle Park, NC 27711.

²See footnote 1 at § 51.859(b)(2).

§ 51.860 Mitigation of air quality impacts.

(a) Any measures that are intended to mitigate air quality impacts must be identified and the process for implementation and enforcement of such measures must be described, including an implementation schedule containing explicit timelines for implementation.

(b) Prior to determining that a Federal action is in conformity, the Federal agency making the conformity determination must obtain written commitments from the appropriate persons or agencies to implement any mitigation measures which are identified as conditions for making conformity determinations.

(c) Persons or agencies voluntarily committing to mitigation measures to facilitate positive conformity determinations must comply with the obligations of such commitments.

(d) In instances where the Federal agency is licensing, permitting or otherwise approving the action of another governmental or private entity, approval by the Federal agency must be conditioned on the other entity meeting the mitigation measures set forth in the conformity determination.

(e) When necessary because of changed circumstances, mitigation measures may be modified so long as the new mitigation measures continue to support the conformity determination. Any proposed change in the mitigation measures is subject to the reporting requirements of § 51.856 and the public participation requirements of § 51.857.

(f) The implementation plan revision required in § 51.851 shall provide that written commitments to mitigation measures must be obtained prior to a positive conformity determination and that such commitments must be fulfilled.

(g) After a State revises its SIP to adopt its general conformity rules and EPA approves that SIP revision, any agreements, including mitigation measures, necessary for a conformity determination will be both State and federally enforceable. Enforceability through the applicable SIP will apply to all persons who agree to mitigate direct and indirect emissions associated

with a Federal action for a conformity determination.

APPENDIXES A-K TO PART 51
[RESERVED]

APPENDIX L TO PART 51—EXAMPLE REGULATIONS FOR PREVENTION OF AIR POLLUTION EMERGENCY EPISODES

The example regulations presented herein reflect generally recognized ways of preventing air pollution from reaching levels that would cause imminent and substantial endangerment to the health of persons. States are required under subpart H to have emergency episode plans but they are not required to adopt the regulations presented herein.

1.0 *Air pollution emergency.* This regulation is designed to prevent the excessive buildup of air pollutants during air pollution episodes, thereby preventing the occurrence of an emergency due to the effects of these pollutants on the health of persons.

1.1 *Episode criteria.* Conditions justifying the proclamation of an air pollution alert, air pollution warning, or air pollution emergency shall be deemed to exist whenever the Director determines that the accumulation of air pollutants in any place is attaining or has attained levels which could, if such levels are sustained or exceeded, lead to a substantial threat to the health of persons. In making this determination, the Director will be guided by the following criteria:

(a) *Air Pollution Forecast:* An internal watch by the Department of Air Pollution Control shall be actuated by a National Weather Service advisory that Atmospheric Stagnation Advisory is in effect or the equivalent local forecast of stagnant atmospheric condition.

(b) *Alert:* The Alert level is that concentration of pollutants at which first stage control actions is to begin. An Alert will be declared when any one of the following levels is reached at any monitoring site:

SO₂—800 µg/m³ (0.3 p.p.m.), 24-hour average.
PM₁₀—350 µg/m³, 24-hour average.
CO—17 mg/m³ (15 p.p.m.), 8-hour average.
Ozone (O₂)—400 µg/m³ (0.2 ppm)-hour average.
NO₂—1130 µg/m³ (0.6 p.p.m.), 1-hour average,
282 µg/m³ (0.15 p.p.m.), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(c) *Warning:* The warning level indicates that air quality is continuing to degrade and that additional control actions are necessary. A warning will be declared when any

one of the following levels is reached at any monitoring site:

SO₂—1,600 µg/m³ (0.6 p.p.m.), 24-hour average.
PM₁₀—420 µg/m³, 24-hour average.
CO—34 mg/m³ (30 p.p.m.), 8-hour average.
Ozone (O₃)—800 µg/m³ (0.4 p.p.m.), 1-hour average.
NO₂—2,260 µg/m³ (1.2 ppm)—1-hour average;
565 µg/m³ (0.3 ppm), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(d) *Emergency:* The emergency level indicates that air quality is continuing to degrade toward a level of significant harm to the health of persons and that the most stringent control actions are necessary. An emergency will be declared when any one of the following levels is reached at any monitoring site:

SO₂—2,100 µg/m³ (0.8 p.p.m.), 24-hour average.
PM₁₀—500 µg/m³, 24-hour average.
CO—46 mg/m³ (40 p.p.m.), 8-hour average.
Ozone (O₃)—1,000 µg/m³ (0.5 p.p.m.), 1-hour average.
NO₂—3,000 µg/m³ (1.6 ppm), 1-hour average; 750 µg/m³ (0.4 ppm), 24-hour average.

In addition to the levels listed for the above pollutants, meteorological conditions are such that pollutant concentrations can be expected to remain at the above levels for twelve (12) or more hours or increase, or in the case of ozone, the situation is likely to reoccur within the next 24-hours unless control actions are taken.

(e) *Termination:* Once declared, any status reached by application of these criteria will remain in effect until the criteria for that level are no longer met. At such time, the next lower status will be assumed.

1.2 *Emission reduction plans.* (a) *Air Pollution Alert:*—When the Director declares an Air Pollution Alert, any person responsible for the operation of a source of air pollutants as set forth in Table I shall take all Air Pollution Alert actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Alert.

(b) *Air Pollution Warning:*—When the Director declares an Air Pollution Warning, any person responsible for the operation of a source of air pollutants as set forth in Table II shall take all Air Pollution Warning actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Warning.

(c) *Air Pollution Emergency:*—When the Director declares an Air Pollution Emergency,

any person responsible for the operation of a source of air pollutants as described in Table III shall take all Air Pollution Emergency actions as required for such source of air pollutants and shall put into effect the preplanned abatement strategy for an Air Pollution Emergency.

(d) When the Director determines that a specified criteria level has been reached at one or more monitoring sites solely because of emissions from a limited number of sources, he shall notify such source(s) that the preplanned abatement strategies of Tables I, II, and III or the standby plans are required, insofar as it applies to such source(s), and shall be put into effect until the criteria of the specified level are no longer met.

1.3 *Preplanned abatement strategies.* (a) Any person responsible for the operation of a source of air pollutants as set forth in Tables I–III shall prepare standby plans for reducing the emission of air pollutants during periods of an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency. Standby plans shall be designed to reduce or eliminate emissions of air pollutants in accordance with the objectives set forth in Tables I–III which are made a part of this section.

(b) Any person responsible for the operation of a source of air pollutants not set forth under section 1.3(a) shall, when requested by the Director in writing, prepare standby plans for reducing the emission of air pollutants during periods of an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency. Standby plans shall be designed to reduce or eliminate emissions of air pollutants in accordance with the objectives set forth in Tables I–III.

(c) Standby plans as required under section 1.3(a) and (b) shall be in writing and identify the sources of air pollutants, the approximate amount of reduction of pollutants and a brief description of the manner in which

the reduction will be achieved during an Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency.

(d) During a condition of Air Pollution Alert, Air Pollution Warning, and Air Pollution Emergency, standby plans as required by this section shall be made available on the premises to any person authorized to enforce the provisions of applicable rules and regulations.

(e) Standby plans as required by this section shall be submitted to the Director upon request within thirty (30) days of the receipt of such request; such standby plans shall be subject to review and approval by the Director. If, in the opinion of the Director, a standby plan does not effectively carry out the objectives as set forth in Table I–III, the Director may disapprove it, state his reason for disapproval and order the preparation of an amended standby plan within the time period specified in the order.

TABLE I—ABATEMENT STRATEGIES EMISSION
REDUCTION PLANS ALERT LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.

2. The use of incinerators for the disposal of any form of solid waste shall be limited to the hours between 12 noon and 4 p.m.

3. Persons operating fuel-burning equipment which required boiler lancing or soot blowing shall perform such operations only between the hours of 12 noon and 4 p.m.

4. Persons operating motor vehicles should eliminate all unnecessary operations.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Alert Level.

Source of air pollution	Control action
1. Coal or oil-fired electric power generating facilities	a. Substantial reduction by utilization of fuels having low ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction by diverting electric power generation to facilities outside of Alert Area.
2. Coal and oil-fired process steam generating facilities	a. Substantial reduction by utilization of fuels having low ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Substantial reduction of steam load demands consistent with continuing plant operations.
3. Manufacturing industries of the following classifications: Primary Metals Industry. Petroleum Refining Operations. Chemical Industries. Mineral Processing Industries. Paper and Allied Products. Grain Industry.	a. Substantial reduction of air pollutants from manufacturing operations by curtailing, postponing, or deferring production and all operations. b. Maximum reduction by deferring trade waste disposal operations which emit solid particles, gas vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing.

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TABLE II—EMISSION REDUCTION PLANS

WARNING LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.
2. The use of incinerators for the disposal of any form of solid waste or liquid waste shall be prohibited.
3. Persons operating fuel-burning equipment which requires boiler lancing or soot

blowing shall perform such operations only between the hours of 12 noon and 4 p.m.

4. Persons operating motor vehicles must reduce operations by the use of car pools and increased use of public transportation and elimination of unnecessary operation.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Warning Level.

Source of air pollution	Control action
1. Coal or oil-fired process steam generating facilities	<ol style="list-style-type: none"> a. Maximum reduction by utilization of fuels having lowest ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Warning Area.
2. Oil and oil-fired process steam generating facilities	<ol style="list-style-type: none"> a. Maximum reduction by utilization of fuels having the lowest available ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Making ready for use a plan of action to be taken if an emergency develops.
3. Manufacturing industries which require considerable lead time for shut-down including the following classifications: Petroleum Refining. Chemical Industries. Primary Metals Industries. Glass Industries. Paper and Allied Products.	<ol style="list-style-type: none"> a. Maximum reduction of air contaminants from manufacturing operations by, if necessary, assuming reasonable economic hardships by postponing production and allied operation. b. Maximum reduction by deferring trade waste disposal operations which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing.
4. Manufacturing industries require relatively short lead times for shut-down including the following classifications: Primary Metals Industries. Chemical Industries. Mineral Processing Industries. Grain Industry.	<ol style="list-style-type: none"> a. Elimination of air pollutants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air pollutants from trade waste disposal processes which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing.

TABLE III—EMISSION REDUCTION PLANS

EMERGENCY LEVEL

Part A. General

1. There shall be no open burning by any persons of tree waste, vegetation, refuse, or debris in any form.
2. The use of incinerators for the disposal of any form of solid or liquid waste shall be prohibited.
3. All places of employment described below shall immediately cease operations.
 - a. Mining and quarrying of nonmetallic minerals.
 - b. All construction work except that which must proceed to avoid emergent physical harm.
 - c. All manufacturing establishments except those required to have in force an air pollution emergency plan.

d. All wholesale trade establishments; i.e., places of business primarily engaged in selling merchandise to retailers, or industrial, commercial, institutional or professional users, or to other wholesalers, or acting as agents in buying merchandise for or selling merchandise to such persons or companies, except those engaged in the distribution of drugs, surgical supplies and food.

e. All offices of local, county and State government including authorities, joint meetings, and other public bodies excepting such agencies which are determined by the chief administrative officer of local, county, or State government, authorities, joint meetings and other public bodies to be vital for public safety and welfare and the enforcement of the provisions of this order.

f. All retail trade establishments except pharmacies, surgical supply distributors, and stores primarily engaged in the sale of food.

g. Banks, credit agencies other than banks, securities and commodities brokers, dealers, exchanges and services; offices of insurance carriers, agents and brokers, real estate offices.

h. Wholesale and retail laundries, laundry services and cleaning and dyeing establishments; photographic studios; beauty shops, barber shops, shoe repair shops.

i. Advertising offices; consumer credit reporting, adjustment and collection agencies; duplicating, addressing, blueprinting; photocopying, mailing, mailing list and stenographic services; equipment rental services, commercial testing laboratories.

j. Automobile repair, automobile services, garages.

k. Establishments rendering amusement and recreational services including motion picture theaters.

l. Elementary and secondary schools, colleges, universities, professional schools, junior colleges, vocational schools, and public and private libraries.

4. All commercial and manufacturing establishments not included in this order will institute such actions as will result in maximum reduction of air pollutants from their operation by ceasing, curtailing, or postponing operations which emit air pollutants to the extent possible without causing injury to persons or damage to equipment.

5. The use of motor vehicles is prohibited except in emergencies with the approval of local or State police.

Part B. Source curtailment

Any person responsible for the operation of a source of air pollutants listed below shall take all required control actions for this Emergency Level.

Source of air pollution	Control action
1. Coal or oil-fired electric power generating facilities	a. Maximum reduction by utilization of fuels having lowest ash and sulfur content. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing. c. Maximum reduction by diverting electric power generation to facilities outside of Emergency Area.
2. Coal and oil-fired process steam generating facilities	a. Maximum reduction by reducing heat and steam demands to absolute necessities consistent with preventing equipment damage. b. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing and soot blowing. c. Taking the action called for in the emergency plan.
3. Manufacturing industries of the following classifications: Primary Metals Industries. Petroleum Refining. Chemical Industries. Mineral Processing Industries. Grain Industry. Paper and Allied Products.	a. Elimination of air pollutants from manufacturing operations by ceasing, curtailing, postponing or deferring production and allied operations to the extent possible without causing injury to persons or damage to equipment. b. Elimination of air pollutants from trade waste disposal processes which emit solid particles, gases, vapors or malodorous substances. c. Maximum reduction of heat load demands for processing. d. Maximum utilization of mid-day (12 noon to 4 p.m.) atmospheric turbulence for boiler lancing or soot blowing.

(Secs. 110, 301(a), 313, 319, Clean Air Act (42 U.S.C. 7410, 7601(a), 7613, 7619))

[36 FR 22398, Nov. 25, 1971; 36 FR 24002, Dec. 17, 1971, as amended at 37 FR 26312, Dec. 9, 1972; 40 FR 36333, Aug. 20, 1975; 41 FR 35676, Aug. 24, 1976; 44 FR 27570, May 10, 1979; 51 FR 40675, Nov. 7, 1986; 52 FR 24714, July 1, 1987]

APPENDIX M TO PART 51—RECOMMENDED TEST METHODS FOR STATE IMPLEMENTATION PLANS

Method 201—Determination of PM₁₀ Emissions (Exhaust Gas Recycle Procedure).

Method 201A—Determination of PM₁₀ Emissions (Constant Sampling Rate Procedure).

Method 202—Determination of Condensable Particulate Emissions From Stationary Sources

Method 204—Criteria for and Verification of a Permanent or Temporary Total Enclosure.

Method 204A—Volatile Organic Compounds Content in Liquid Input Stream.

Method 204B—Volatile Organic Compounds Emissions in Captured Stream.

Method 204C—Volatile Organic Compounds Emissions in Captured Stream (Dilution Technique).

Method 204D—Volatile Organic Compounds Emissions in Uncaptured Stream from Temporary Total Enclosure.

Method 204E—Volatile Organic Compounds Emissions in Uncaptured Stream from Building Enclosure.

Method 204F—Volatile Organic Compounds Content in Liquid Input Stream (Distillation Approach).

Method 205—Verification of Gas Dilution Systems for Field Instrument Calibrations

Presented herein are recommended test methods for measuring air pollutant emanating from an emission source. They are provided for States to use in their plans to meet the requirements of subpart K—Source Surveillance.

The State may also choose to adopt other methods to meet the requirements of subpart K of this part, subject to the normal plan review process.

The State may also meet the requirements of subpart K of this part by adopting, again subject to the normal plan review process, any of the relevant methods in appendix A to 40 CFR part 60.

METHOD 201—DETERMINATION OF PM₁₀ EMISSIONS

(EXHAUST GAS RECYCLE PROCEDURE)

1. Applicability and Principle

1.1 Applicability. This method applies to the in-stack measurement of particulate matter (PM) emissions equal to or less than an aerodynamic diameter of nominally 10 µm (PM₁₀) from stationary sources. The EPA recognizes that condensible emissions not collected by an in-stack method are also PM₁₀, and that emissions that contribute to ambient PM₁₀ levels are the sum of condensible emissions and emissions measured by an in-stack PM₁₀ method, such as this method or Method 201A. Therefore, for establishing source contributions to ambient levels of PM₁₀, such as for emission inventory purposes, EPA suggests that source PM₁₀ measurement include both in-stack PM₁₀ and condensible emissions. Condensible emissions may be measured by an impinger analysis in combination with this method.

1.2 Principle. A gas sample is isokinetically extracted from the source. An in-stack cyclone is used to separate PM greater than PM₁₀, and an in-stack glass fiber filter is used to collect the PM₁₀. To maintain isokinetic flow rate conditions at the tip of the probe and a constant flow rate through the cyclone, a clean, dried portion of the sample gas at stack temperature is recycled into the nozzle. The particulate mass is determined gravimetrically after removal of uncombined water.

2. Apparatus

NOTE: Method 5 as cited in this method refers to the method in 40 CFR part 60, appendix A.

2.1 Sampling Train. A schematic of the exhaust of the exhaust gas recycle (EGR) train is shown in Figure 1 of this method.

2.1.1 Nozzle with Recycle Attachment. Stainless steel (316 or equivalent) with a sharp tapered leading edge, and recycle attachment welded directly on the side of the nozzle (see schematic in Figure 2 of this method). The angle of the taper shall be on the outside. Use only straight sampling nozzles. "Gooseneck" or other nozzle extensions designed to turn the sample gas flow 90°, as in Method 5 are not acceptable. Locate a thermocouple in the recycle attachment to measure the temperature of the recycle gas as shown in Figure 3 of this method. The recycle attachment shall be made of stainless steel and shall be connected to the probe and nozzle with stainless steel fittings. Two nozzle sizes, e.g., 0.125 and 0.160 in., should be available to allow isokinetic sampling to be conducted over a range of flow rates. Calibrate each nozzle as described in Method 5, Section 5.1.

2.1.2 PM₁₀ Sizer. Cyclone, meeting the specifications in Section 5.7 of this method.

2.1.3 Filter Holder. 63mm, stainless steel. An Andersen filter, part number SE274, has been found to be acceptable for the in-stack filter.

NOTE: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.1.4 Pitot Tube. Same as in Method 5, Section 2.1.3. Attach the pitot to the pitot lines with stainless steel fittings and to the cyclone in a configuration similar to that shown in Figure 3 of this method. The pitot lines shall be made of heat resistant material and attached to the probe with stainless steel fittings.

2.1.5 EGR Probe. Stainless steel, 15.9-mm (5/8-in.) ID tubing with a probe liner, stainless steel 9.53-mm (3/8-in.) ID stainless steel recycle tubing, two 6.35-mm (1/4-in.) ID stainless steel tubing for the pitot tube extensions, three thermocouple leads, and one power lead, all contained by stainless steel tubing with a diameter of approximately 51 mm (2.0 in.). Design considerations should include minimum weight construction materials sufficient for probe structural strength. Wrap the sample and recycle tubes with a heating tape to heat the sample and recycle gases to stack temperature.

2.1.6 Condenser. Same as in Method 5, Section 2.1.7.

2.1.7 Umbilical Connector. Flexible tubing with thermocouple and power leads of sufficient length to connect probe to meter and flow control console.

2.1.8 Vacuum Pump. Leak-tight, oil-less, noncontaminating, with an absolute filter, "HEPA" type, at the pump exit. A Gast Model 0522-V103 G18DX pump has been found to be satisfactory.

2.1.9 Meter and Flow Control Console. System consisting of a dry gas meter and calibrated orifice for measuring sample flow rate

and capable of measuring volume to ± 2 percent, calibrated laminar flow elements (LFE's) or equivalent for measuring total and sample flow rates, probe heater control, and manometers and magnehelic gauges (as shown in Figures 4 and 5 of this method), or equivalent. Temperatures needed for calculations include stack, recycle, probe, dry gas meter, filter, and total flow. Flow measurements include velocity head (Δp), orifice differential pressure (ΔH), total flow, recycle flow, and total back-pressure through the system.

2.1.10 Barometer. Same as in Method 5, Section 2.1.9.

2.1.11 Rubber Tubing. 6.35-mm ($\frac{1}{4}$ -in.) ID flexible rubber tubing.

2.2 Sample Recovery.

2.2.1 Nozzle, Cyclone, and Filter Holder Brushes. Nylon bristle brushes properly sized and shaped for cleaning the nozzle, cyclone, filter holder, and probe or probe liner, with stainless steel wire shafts and handles.

2.2.2 Wash Bottles, Glass Sample Storage Containers, Petri Dishes, Graduated Cylinder and Balance, Plastic Storage Containers, and Funnels. Same as Method 5, Sections 2.2.2 through 2.2.6 and 2.2.8, respectively.

2.3 Analysis. Same as in Method 5, Section 2.3.

3. Reagents

The reagents used in sampling, sample recovery, and analysis are the same as that specified in Method 5, Sections 3.1, 3.2, and 3.3, respectively.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. Same as in Method 5, Section 4.1.1.

4.1.2 Preliminary Determinations. Same as Method 5, Section 4.1.2, except use the directions on nozzle size selection in this section. Use of the EGR method may require a minimum sampling port diameter of 0.2 m (6 in.). Also, the required maximum number of sample traverse points at any location shall be 12.

4.1.2.1 The cyclone and filter holder must be in-stack or at stack temperature during sampling. The blockage effects of the EGR sampling assembly will be minimal if the cross-sectional area of the sampling assembly is 3 percent or less of the cross-sectional area of the duct and a pitot coefficient of 0.84 may be assigned to the pitot. If the cross-sectional area of the assembly is greater than 3 percent of the cross-sectional area of the duct, then either determine the pitot coefficient at sampling conditions or use a standard pitot with a known coefficient in a configuration with the EGR sampling assembly

such that flow disturbances are minimized.

4.1.2.2 Construct a setup of pressure drops for various Δp 's and temperatures. A computer is useful for these calculations. An example of the output of the EGR setup program is shown in Figure 6 of this method, and directions on its use are in section 4.1.5.2 of this method. Computer programs, written in IBM BASIC computer language, to do these types of setup and reduction calculations for the EGR procedure, are available through the National Technical Information Services (NTIS), Accession number PB90-500000, 5285 Port Royal Road, Springfield, VA 22161.

4.1.2.3 The EGR setup program allows the tester to select the nozzle size based on anticipated average stack conditions and prints a setup sheet for field use. The amount of recycle through the nozzle should be between 10 and 80 percent. Inputs for the EGR setup program are stack temperature (minimum, maximum, and average), stack velocity (minimum, maximum, and average), atmospheric pressure, stack static pressure, meter box temperature, stack moisture, percent O_2 , and percent CO_2 in the stack gas, pitot coefficient (C_p), orifice ΔH , flow rate measurement calibration values [slope (m) and y-intercept (b) of the calibration curve], and the number of nozzles available and their diameters.

4.1.2.4 A less rigorous calculation for the setup sheet can be done manually using the equations on the example worksheets in Figures 7, 8, and 9 of this method, or by a Hewlett-Packard HP41 calculator using the program provided in appendix D of the EGR operators manual, entitled *Applications Guide for Source PM_{10} Exhaust Gas Recycle Sampling System*. This calculation uses an approximation of the total flow rate and agrees within 1 percent of the exact solution for pressure drops at stack temperatures from 38 to 260 °C (100 to 500 °F) and stack moisture up to 50 percent. Also, the example worksheets use a constant stack temperature in the calculation, ignoring the complicated temperature dependence from all three pressure drop equations. Errors for this at stack temperatures ± 28 °C (± 50 °F) of the temperature used in the setup calculations are within 5 percent for flow rate and within 5 percent for cyclone cut size.

4.1.2.5 The pressure upstream of the LFE's is assumed to be constant at 0.6 in. Hg in the EGR setup calculations.

4.1.2.6 The setup sheet constructed using this procedure shall be similar to Figure 6 of this method. Inputs needed for the calculation are the same as for the setup computer except that stack velocities are not needed.

4.1.3 Preparation of Collection Train. Same as in Method 5, Section 4.1.3, except use the following directions to set up the train.

4.1.3.1 Assemble the EGR sampling device, and attach it to probe as shown in Figure 3 of this method. If stack temperatures exceed 260 °C (500 °F), then assemble the EGR cyclone without the O-ring and reduce the vacuum requirement to 130 mm Hg (5.0 in. Hg) in the leak-check procedure in Section 4.1.4.3.2 of this method.

4.1.3.2 Connect the probe directly to the filter holder and condenser as in Method 5. Connect the condenser and probe to the meter and flow control console with the umbilical connector. Plug in the pump and attach pump lines to the meter and flow control console.

4.1.4 Leak-Check Procedure. The leak-check for the EGR Method consists of two parts: the sample-side and the recycle-side. The sample-side leak-check is required at the beginning of the run with the cyclone attached, and after the run with the cyclone removed. The cyclone is removed before the post-test leak-check to prevent any disturbance of the collected sample prior to analysis. The recycle-side leak-check tests the leak tight integrity of the recycle components and is required prior to the first test run and after each shipment.

4.1.4.1 Pretest Leak-Check. A pretest leak-check of the entire sample-side, including the cyclone and nozzle, is required. Use the leak-check procedure in Section 4.1.4.3 of this method to conduct a pretest leak-check.

4.1.4.2 Leak-Checks During Sample Run. Same as in Method 5, Section 4.1.4.1.

4.1.4.3 Post-Test Leak-Check. A leak-check is required at the conclusion of each sampling run. Remove the cyclone before the leak-check to prevent the vacuum created by the cooling of the probe from disturbing the collected sample and use the following procedure to conduct a post-test leak-check.

4.1.4.3.1 The sample-side leak-check is performed as follows: After removing the cyclone, seal the probe with a leak-tight stopper. Before starting pump, close the coarse total valve and both recycle valves, and open completely the sample back pressure valve and the fine total valve. After turning the pump on, partially open the coarse total valve slowly to prevent a surge in the manometer. Adjust the vacuum to at least 381 mm Hg (15.0 in. Hg) with the fine total valve. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak-check as shown below and start over.

CAUTION: Do not decrease the vacuum with any of the valves. This may cause a rupture of the filter.

NOTE: A lower vacuum may be used, provided that it is not exceeded during the test.

4.1.4.3.2 Leak rates in excess of 0.00057 m³/min (0.020 ft³/min) are unacceptable. If the leak rate is too high, void the sampling run.

4.1.4.3.3 To complete the leak-check, slowly remove the stopper from the nozzle until the vacuum is near zero, then immediately turn off the pump. This procedure sequence prevents a pressure surge in the manometer fluid and rupture of the filter.

4.1.4.3.4 The recycle-side leak-check is performed as follows: Close the coarse and fine total valves and sample back pressure valve. Plug the sample inlet at the meter box. Turn on the power and the pump, close the recycle valves, and open the total flow valves. Adjust the total flow fine adjust valve until a vacuum of 25 inches of mercury is achieved. If the desired vacuum is exceeded, either leak-check at this higher vacuum, or end the leak-check and start over. Minimum acceptable leak rates are the same as for the sample-side. If the leak rate is too high, void the sampling run.

4.1.5 EGR Train Operation. Same as in Method 5, Section 4.1.5, except omit references to nomographs and recommendations about changing the filter assembly during a run.

4.1.5.1 Record the data required on a data sheet such as the one shown in Figure 10 of this method. Make periodic checks of the manometer level and zero to ensure correct ΔH and Δp values. An acceptable procedure for checking the zero is to equalize the pressure at both ends of the manometer by pulling off the tubing, allowing the fluid to equilibrate and, if necessary, to re-zero. Maintain the probe temperature to within 11 °C (20 °F) of stack temperature.

4.1.5.2 The procedure for using the example EGR setup sheet is as follows: Obtain a stack velocity reading from the pitot manometer (Δp), and find this value on the ordinate axis of the setup sheet. Find the stack temperature on the abscissa. Where these two values intersect are the differential pressures necessary to achieve isokineticity and 10 μ m cut size (interpolation may be necessary).

4.1.5.3 The top three numbers are differential pressures (in. H₂O), and the bottom number is the percent recycle at these flow settings. Adjust the total flow rate valves, coarse and fine, to the sample value (ΔH) on the setup sheet, and the recycle flow rate valves, coarse and fine, to the recycle flow on the setup sheet.

4.1.5.4 For startup of the EGR sample train, the following procedure is recommended. Preheat the cyclone in the stack for 30 minutes. Close both the sample and recycle coarse valves. Open the fine total, fine recycle, and sample back pressure valves halfway. Ensure that the nozzle is properly aligned with the sample stream. After noting the Δp and stack temperature, select the appropriate ΔH and recycle from the EGR setup sheet. Start the pump and timing device simultaneously. Immediately open both the coarse total and the coarse recycle valves slowly to obtain the approximate desired

values. Adjust both the fine total and the fine recycle valves to achieve more precisely the desired values. In the EGR flow system, adjustment of either valve will result in a change in both total and recycle flow rates, and a slight iteration between the total and recycle valves may be necessary. Because the sample back pressure valve controls the total flow rate through the system, it may be necessary to adjust this valve in order to obtain the correct flow rate.

NOTE: Isokinetic sampling and proper operation of the cyclone are not achieved unless the correct ΔH and recycle flow rates are maintained.

4.1.5.5 During the test run, monitor the probe and filter temperatures periodically, and make adjustments as necessary to maintain the desired temperatures. If the sample loading is high, the filter may begin to blind or the cyclone may clog. The filter or the cyclone may be replaced during the sample run. Before changing the filter or cyclone, conduct a leak-check (Section 4.1.4.2 of this method). The total particulate mass shall be the sum of all cyclone and the filter catch during the run. Monitor stack temperature and Δp periodically, and make the necessary adjustments in sampling and recycle flow rates to maintain isokinetic sampling and the proper flow rate through the cyclone. At the end of the run, turn off the pump, close the coarse total valve, and record the final dry gas meter reading. Remove the probe from the stack, and conduct a post-test leak-check as outlined in Section 4.1.4.3 of this method.

4.2 Sample Recovery. Allow the probe to cool. When the probe can be safely handled, wipe off all external PM adhering to the outside of the nozzle, cyclone, and nozzle attachment, and place a cap over the nozzle to prevent losing or gaining PM. Do not cap the nozzle tip tightly while the sampling train is cooling, as this action would create a vacuum in the filter holder. Disconnect the probe from the umbilical connector, and take the probe to the cleanup site. Sample recovery should be conducted in a dry indoor area or, if outside, in an area protected from wind and free of dust. Cap the ends of the impingers and carry them to the cleanup site. Inspect the components of the train prior to and during disassembly to note any abnormal conditions. Disconnect the pitot from the cyclone. Remove the cyclone from the probe. Recover the sample as follows:

4.2.1 *Container Number 1* (Filter). The recovery shall be the same as that for Container Number 1 in Method 5, Section 4.2.

4.2.2 *Container Number 2* (Cyclone or Large PM Catch). The cyclone must be disassembled and the nozzle removed in order to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and the cyclone, excluding the "turn around" cup and the interior surfaces

of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.3 *Container Number 3* (PM_{10}). Quantitatively recover the PM from all of the surfaces from cyclone exit to the front half of the in-stack filter holder, including the "turn around" cup and the interior of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.4 *Container Number 4* (Silica Gel). Same as that for Container Number 3 in Method 5, Section 4.2.

4.2.5 *Impinger Water*. Same as in Method 5, Section 4.2, under "Impinger Water."

4.3 Analysis. Same as in Method 5, Section 4.3, except handle EGR Container Numbers 1 and 2 like Container Number 1 in Method 5, EGR Container Numbers 3, 4, and 5 like Container Number 3 in Method 5, and EGR Container Number 6 like Container Number 3 in Method 5. Use Figure 11 of this method to record the weights of PM collected.

4.4 Quality Control Procedures. Same as in Method 5, Section 4.4.

4.5 PM_{10} Emission Calculation and Acceptability of Results. Use the EGR reduction program or the procedures in section 6 of this method to calculate PM_{10} emissions and the criteria in section 6.7 of this method to determine the acceptability of the results.

5. Calibration

Maintain an accurate laboratory log of all calibrations.

5.1 Probe Nozzle. Same as in Method 5, Section 5.1.

5.2 Pitot Tube. Same as in Method 5, Section 5.2.

5.3 Meter and Flow Control Console.

5.3.1 Dry Gas Meter. Same as in Method 5, Section 5.3.

5.3.2 LFE Gauges. Calibrate the recycle, total, and inlet total LFE gauges with a manometer. Read and record flow rates at 10, 50, and 90 percent of full scale on the total and recycle pressure gauges. Read and record flow rates at 10, 20, and 30 percent of full scale on the inlet total LFE pressure gauge. Record the total and recycle readings to the nearest 0.3 mm (0.01 in.). Record the inlet total LFE readings to the nearest 3 mm (0.1 in.). Make three separate measurements at each setting and calculate the average. The maximum difference between the average pressure reading and the average manometer reading shall not exceed 1 mm (0.05 in.). If the differences exceed the limit specified, adjust or replace the pressure gauge. After each field use, check the calibration of the pressure gauges.

5.3.3 Total LFE. Same as the metering system in Method 5, Section 5.3.

5.3.4 Recycle LFE. Same as the metering system in Method 5, Section 5.3, except completely close both the coarse and fine recycle valves.

5.4 Probe Heater. Connect the probe to the meter and flow control console with the umbilical connector. Insert a thermocouple into the probe sample line approximately half the length of the probe sample line. Calibrate the probe heater at 66°C (150°F), 121°C (250°F), and 177°C (350°F). Turn on the power, and set the probe heater to the specified temperature. Allow the heater to equilibrate, and record the thermocouple temperature and the meter and flow control console temperature to the nearest 0.5°C (1°F). The two temperatures should agree within 5.5°C (10°F). If this agreement is not met, adjust or replace the probe heater controller.

5.5 Temperature Gauges. Connect all thermocouples, and let the meter and flow control console equilibrate to ambient temperature. All thermocouples shall agree to within 1.1°C (2.0°F) with a standard mercury-in-glass thermometer. Replace defective thermocouples.

5.6 Barometer. Calibrate against a standard mercury-in-glass barometer.

5.7 Probe Cyclone and Nozzle Combinations. The probe cyclone and nozzle combinations need not be calibrated if the cyclone meets the design specifications in Figure 12 of this method and the nozzle meets the design specifications in appendix B of the *Application Guide for the Source PM₁₀ Exhaust Gas Recycle Sampling System*, EPA/600/3-88-058. This document may be obtained from Roy Huntley at (919) 541-1060. If the nozzles do not meet the design specifications, then test the cyclone and nozzle combination for conformity with the performance specifications (PS's) in Table 1 of this method. The purpose of the PS tests is to determine if the cyclone's sharpness of cut meets minimum performance criteria. If the cyclone does not meet design specifications, then, in addition to the cyclone and nozzle combination conforming to the PS's, calibrate the cyclone and determine the relationship between flow rate, gas viscosity, and gas density. Use the procedures in Section 5.7.5 of this method to conduct PS tests and the procedures in Section 5.8 of this method to calibrate the cyclone. Conduct the PS tests in a wind tunnel described in Section 5.7.1 of this method and using a particle generation system described in Section 5.7.2 of this method. Use five particle sizes and three wind velocities as listed in Table 2 of this method. Perform a minimum of three replicate measurements of collection efficiency for each of the 15 conditions listed, for a minimum of 45 measurements.

5.7.1 Wind Tunnel. Perform calibration and PS tests in a wind tunnel (or equivalent test apparatus) capable of establishing and main-

taining the required gas stream velocities within 10 percent.

5.7.2 Particle Generation System. The particle generation system shall be capable of producing solid monodispersed dye particles with the mass median aerodynamic diameters specified in Table 2 of this method. The particle size distribution verification should be performed on an integrated sample obtained during the sampling period of each test. An acceptable alternative is to verify the size distribution of samples obtained before and after each test, with both samples required to meet the diameter and monodispersity requirements for an acceptable test run.

5.7.2.1 Establish the size of the solid dye particles delivered to the test section of the wind tunnel using the operating parameters of the particle generation system, and verify the size during the tests by microscopic examination of samples of the particles collected on a membrane filter. The particle size, as established by the operating parameters of the generation system, shall be within the tolerance specified in Table 2 of this method. The precision of the particle size verification technique shall be at least ± 0.5 μm , and the particle size determined by the verification technique shall not differ by more than 10 percent from that established by the operating parameters of the particle generation system.

5.7.2.2 Certify the monodispersity of the particles for each test either by microscopic inspection of collected particles on filters or by other suitable monitoring techniques such as an optical particle counter followed by a multichannel pulse height analyzer. If the proportion of multiplets and satellites in an aerosol exceeds 10 percent by mass, the particle generation system is unacceptable for purposes of this test. Multiplets are particles that are agglomerated, and satellites are particles that are smaller than the specified size range.

5.7.3 Schematic Drawings. Schematic drawings of the wind tunnel and blower system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be furnished with calibration data to the reviewing agency.

5.7.4 Flow Rate Measurement. Determine the cyclone flow rates with a dry gas meter and a stopwatch, or a calibrated orifice system capable of measuring flow rates to within 2 percent.

5.7.5 Performance Specification Procedure. Establish the test particle generator operation and verify the particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements may be made at this time.

5.7.5.1 The cyclone cut size (D_{50}) is defined as the aerodynamic diameter of a particle having a 50 percent probability of penetration. Determine the required cyclone flow rate at which D_{50} is 10 μm . A suggested procedure is to vary the cyclone flow rate while keeping a constant particle size of 10 μm . Measure the PM collected in the cyclone (m_c), exit tube (m_t), and filter (m_f). Compute the cyclone efficiency (E_c) as follows:

$$E_c = \frac{m_c}{(m_c + m_t + m_f)} \times 100$$

$$\sigma = \left[\frac{(E_1^2 + E_2^2 + E_3^2) - \frac{(E_1 + E_2 + E_3)^2}{3}}{2} \right]^{\frac{1}{2}}$$

if σ exceeds 0.10, repeat the replicate runs.

5.7.5.4 Using the cyclone flow rate that produces D_{50} for 10 μm , measure the overall efficiency of the cyclone and nozzle, E_o , at the particle sizes and nominal gas velocities in Table 2 of this method using this following procedure.

5.7.5.5 Set the air velocity in the wind tunnel to one of the nominal gas velocities from Table 2 of this method. Establish isokinetic sampling conditions and the correct flow rate through the sampler (cyclone and nozzle) using recycle capacity so that the D_{50} is 10 μm . Sample long enough to obtain ± 5 percent precision on the total collected mass as determined by the precision and the sensitivity of the measuring technique. Determine separately the nozzle catch (m_n), cyclone catch (m_c), cyclone exit tube catch (m_t), and collection filter catch (m_f).

5.7.5.6 Calculate the overall efficiency (E_o) as follows:

$$E_o = \frac{(m_n + m_c)}{(m_n + m_c + m_t + m_f)} \times 100$$

5.7.5.7 Do three replicates for each combination of gas velocities and particle sizes in Table 2 of this method. Calculate E_o for each particle size following the procedures described in this section for determining efficiency. Calculate the standard deviation (σ) for the replicate measurements. If σ exceeds 0.10, repeat the replicate runs.

5.7.6 Criteria for Acceptance. For each of the three gas stream velocities, plot the av-

5.7.5.2 Perform three replicates and calculate the average cyclone efficiency as follows:

$$E_{\text{avg}} = \frac{(E_1 + E_2 + E_3)}{3}$$

where E_1 , E_2 , and E_3 are replicate measurements of E_c .

5.7.5.3 Calculate the standard deviation (σ) for the replicate measurements of E_c as follows:

erage E_o as a function of particle size on Figure 13 of this method. Draw a smooth curve for each velocity through all particle sizes. The curve shall be within the banded region for all sizes, and the average E_c for a D_{50} for 10 μm shall be 50 ± 0.5 percent.

5.8 Cyclone Calibration Procedure. The purpose of this section is to develop the relationship between flow rate, gas viscosity, gas density, and D_{50} . This procedure only needs to be done on those cyclones that do not meet the design specifications in Figure 12 of this method.

5.8.1 Calculate cyclone flow rate. Determine the flow rates and D_{50} 's for three different particle sizes between 5 μm and 15 μm , one of which shall be 10 μm . All sizes must be within 0.5 μm . For each size, use a different temperature within 60 °C (108 °F) of the temperature at which the cyclone is to be used and conduct triplicate runs. A suggested procedure is to keep the particle size constant and vary the flow rate. Some of the values obtained in the PS tests in Section 5.7.5 may be used.

5.8.1.1 On log-log graph paper, plot the Reynolds number (Re) on the abscissa, and the square root of the Stokes 50 number $[(STK_{50})^{1/2}]$ on the ordinate for each temperature. Use the following equations:

$$Re = \frac{4\rho Q_{\text{cyc}}}{d_{\text{cyc}} \pi \mu_{\text{cyc}}}$$

$$(\text{Stk}_{50})^{\frac{1}{2}} = \left[\frac{4Q_{\text{cyc}}(D_{50})^2}{9\pi \mu_{\text{cyc}}(d_{\text{cyc}})^3} \right]^{\frac{1}{2}}$$

where:

Q_{cyc} = Cyclone flow rate cm^3/sec .

ρ = Gas density, g/cm^3 .

d_{cyc} = Diameter of cyclone inlet, cm.

μ_{cyc} = Viscosity of gas through the cyclone, poise.

D_{50} = Cyclone cut size, cm.

5.8.1.2 Use a linear regression analysis to determine the slope (m), and the y-intercept (b). Use the following formula to determine Q , the cyclone flow rate required for a cut size of $10 \mu\text{m}$.

$$Q = \frac{\pi \mu_{\text{cyc}}}{4} \left[(3000)(K_1)^b \right] - (0.5 - m) \left[\frac{T_s}{M_c P_s} \right] m / (m - 0.5)^{(m-1.5)/(m-0.5)}$$

where:

Q = Cyclone flow rate for a cut size of $10 \mu\text{m}$, cm^3/sec .

T_s = Stack gas temperature, $^{\circ}\text{K}$.

d = Diameter of nozzle, cm.

$K_1 = 4.077 \times 10^{-3}$.

5.8.2. Directions for Using Q . Refer to Section 5 of the EGR operators manual for directions in using this expression for Q in the setup calculations.

6. Calculations

6.1 The EGR data reduction calculations are performed by the EGR reduction computer program, which is written in IBM BASIC computer language and is available through NTIS, Accession number PB90-500000, 5285 Port Royal Road, Springfield, Virginia 22161. Examples of program inputs and outputs are shown in Figure 14 of this method.

6.1.1 Calculations can also be done manually, as specified in Method 5, Sections 6.3 through 6.7, and 6.9 through 6.12, with the addition of the following:

6.1.2 Nomenclature.

B_c = Moisture fraction of mixed cyclone gas, by volume, dimensionless.

C_1 = Viscosity constant, 51.12 micropoise for $^{\circ}\text{K}$ (51.05 micropoise for $^{\circ}\text{R}$).

C_2 = Viscosity constant, 0.372 micropoise/ $^{\circ}\text{K}$ (0.207 micropoise/ $^{\circ}\text{R}$).

C_3 = Viscosity constant, 1.05×10^{-4} micropoise/ $^{\circ}\text{K}^2$ (3.24×10^{-5} micropoise/ $^{\circ}\text{R}^2$).

C_4 = Viscosity constant, 53.147 micropoise/fraction O_2 .

C_5 = Viscosity constant, 74.143 micropoise/fraction H_2O .

D_{50} = Diameter of particles having a 50 percent probability of penetration, μm .

f_{O_2} = Stack gas fraction O_2 , by volume, dry basis.

$K_1 = 0.3858 \text{ } ^{\circ}\text{K}/\text{mm Hg}$ ($17.64 \text{ } ^{\circ}\text{R}/\text{in. Hg}$).

M_c = Wet molecular weight of mixed gas through the PM_{10} cyclone, $\text{g}/\text{g-mole}$ ($\text{lb}/\text{lb-mole}$).

M_d = Dry molecular weight of stack gas, $\text{g}/\text{g-mole}$ ($\text{lb}/\text{lb-mole}$).

P_{bar} = Barometer pressure at sampling site, mm Hg (in. Hg).

P_{in1} = Gauge pressure at inlet to total LFE, mm H_2O (in. H_2O).

P_3 = Absolute stack pressure, mm Hg (in. Hg).

Q_2 = Total cyclone flow rate at wet cyclone conditions, m^3/min (ft^3/min).

$Q_{\text{s(std)}}$ = Total cyclone flow rate at standard conditions, dscm/min (dscf/min).

T_m = Average temperature of dry gas meter, $^{\circ}\text{K}$ ($^{\circ}\text{R}$).

T_s = Average stack gas temperature, $^{\circ}\text{K}$ ($^{\circ}\text{R}$).

$V_{\text{w(std)}}$ = Volume of water vapor in gas sample (standard conditions), scm (scf).

X_T = Total LFE linear calibration constant, $\text{m}^3/[(\text{min})(\text{mm H}_2\text{O})]$ { $\text{ft}^3/[(\text{min})(\text{in. H}_2\text{O})]$ }.

Y_T = Total LFE linear calibration constant, dscm/min (dscf/min).

ΔP_T = Pressure differential across total LFE, mm H_2O , (in. H_2O).

θ = Total sampling time, min.

μ_{cyc} = Viscosity of mixed cyclone gas, micropoise.

μ_{LFE} = Viscosity of gas laminar flow elements, micropoise.

μ_{std} = Viscosity of standard air, 180.1 micropoise.

6.2 PM_{10} Particulate Weight. Determine the weight of PM_{10} by summing the weights obtained from Container Numbers 1 and 3, less the acetone blank.

6.3 Total Particulate Weight. Determine the particulate catch for PM greater than PM_{10} from the weight obtained from Container Number 2 less the acetone blank, and add it to the PM_{10} particulate weight.

6.4 PM_{10} Fraction. Determine the PM_{10} fraction of the total particulate weight by dividing the PM_{10} particulate weight by the total particulate weight.

6.5 Total Cyclone Flow Rate. The average flow rate at standard conditions is determined from the average pressure drop across the total LFE and is calculated as follows:

$$Q_{s(\text{std})} = K_1 \left[X_T \Delta P \frac{\mu_{\text{std}}}{\mu_{\text{LFE}}} + Y_T \right] \frac{P_{\text{bar}} + P_{\text{inl}}/13.6}{T_m}$$

The flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{s(\text{std})} + \frac{V_{m(\text{std})}}{\theta} \right]$$

The flow rate, at actual cyclone conditions, is calculated as follows:

$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{s(\text{std})} + \frac{V_{m(\text{std})}}{\theta} \right]$$

6.6 Aerodynamic Cut Size. Use the following procedure to determine the aerodynamic cut size (D_{50}).

6.6.1 Determine the water fraction of the mixed gas through the cyclone by using the equation below.

$$B_c = \frac{V_{w(\text{std})}}{Q_{s(\text{std})} \theta + V_{w(\text{std})}}$$

6.6.2 Calculate the cyclone gas viscosity as follows:

$$\mu_{\text{cyc}} = C_1 + C_2 T_s + C_3 T_s^2 + C_4 f_{02} - C_5 B_c$$

6.6.3 Calculate the molecular weight on a wet basis of the cyclone gas as follows:

$$M_c = M_d(1 - B_c) + 18.0(B_c)$$

6.6.4 If the cyclone meets the design specification in Figure 12 of this method, calculate the actual D_{50} of the cyclone for the run as follows:

$$D_{50} = \beta_1 \left[\frac{T_s}{M_c P_s} \right] \frac{0.2.091}{\left[\frac{\mu_{\text{cyc}}}{Q_s} \right]} \frac{0.7091}{\left[\frac{\mu_{\text{cyc}}}{Q_s} \right]}$$

where $\beta_1 = 0.1562$.

6.6.5 If the cyclone does not meet the design specifications in Figure 12 of this method, then use the following equation to calculate D_{50} .

od, then use the following equation to calculate D_{50} .

$$D_{50} = (3)(10)^b \left(7.376 \times 10^{-4} \right)^m \left[\frac{M_c P_s}{T_s} \right] \left[\frac{4 Q_s}{\pi \mu_{\text{cyc}}} \right] d^{(1.5-m)}$$

where:

m = Slope of the calibration curve obtained in Section 5.8.2.

b = y-intercept of the calibration curve obtained in Section 5.8.2.

6.7 Acceptable Results. Acceptability of anisokinetic variation is the same as Method 5, Section 6.12.

6.7.1 If $9.0 \mu\text{m} \leq D_{50} \leq 11 \mu\text{m}$ and $90 \leq I \leq 110$, the results are acceptable. If D_{50} is greater than $11 \mu\text{m}$, the Administrator may accept the results. If D_{50} is less than $9.0 \mu\text{m}$, reject the results and repeat the test.

7. Bibliography

1. Same as Bibliography in Method 5.

2. McCain, J.D., J.W. Ragland, and A.D. Williamson. Recommended Methodology for the Determination of Particles Size Distributions in Ducted Sources, Final Report. Prepared for the California Air Resources Board by Southern Research Institute. May 1986.

3. Farthing, W.E., S.S. Dawes, A.D. Williamson, J.D. McCain, R.S. Martin, and J.W. Ragland. Development of Sampling Methods for Source PM_{10} Emissions. Southern Research Institute for the Environmental Protection Agency. April 1989.

4. Application Guide for the Source PM_{10} Exhaust Gas Recycle Sampling System, EPA/600/3-88-058.

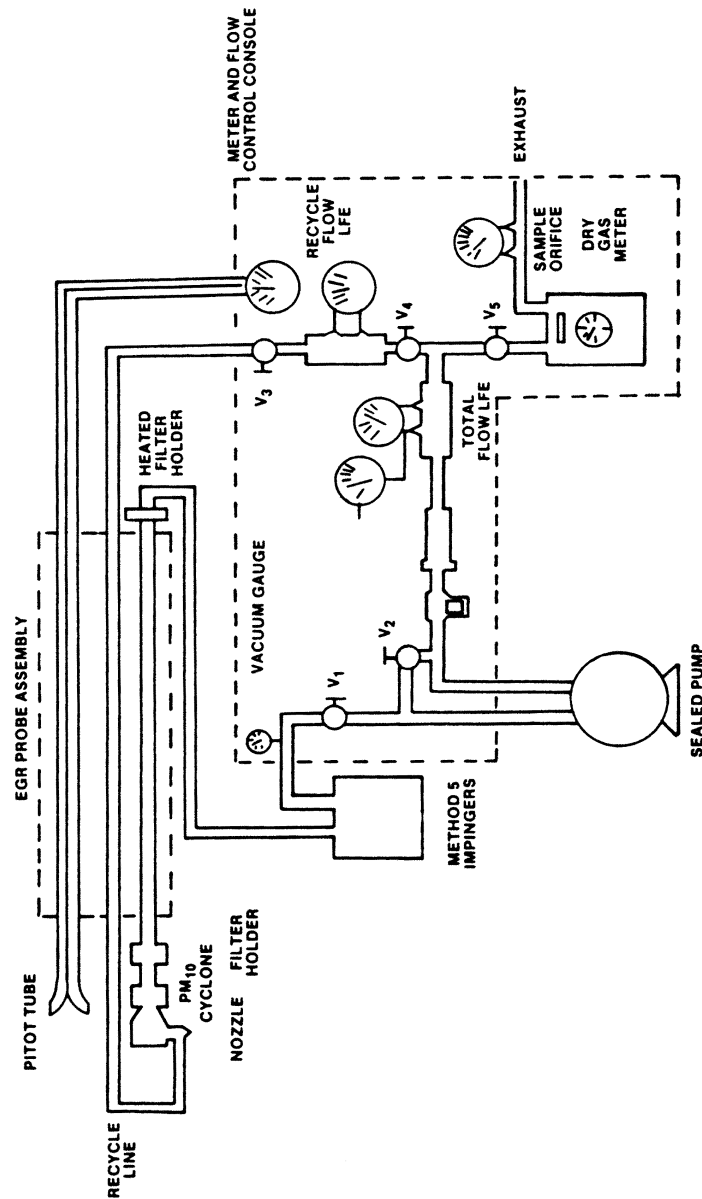


Figure 1. Schematic of the exhaust gas recycle train.

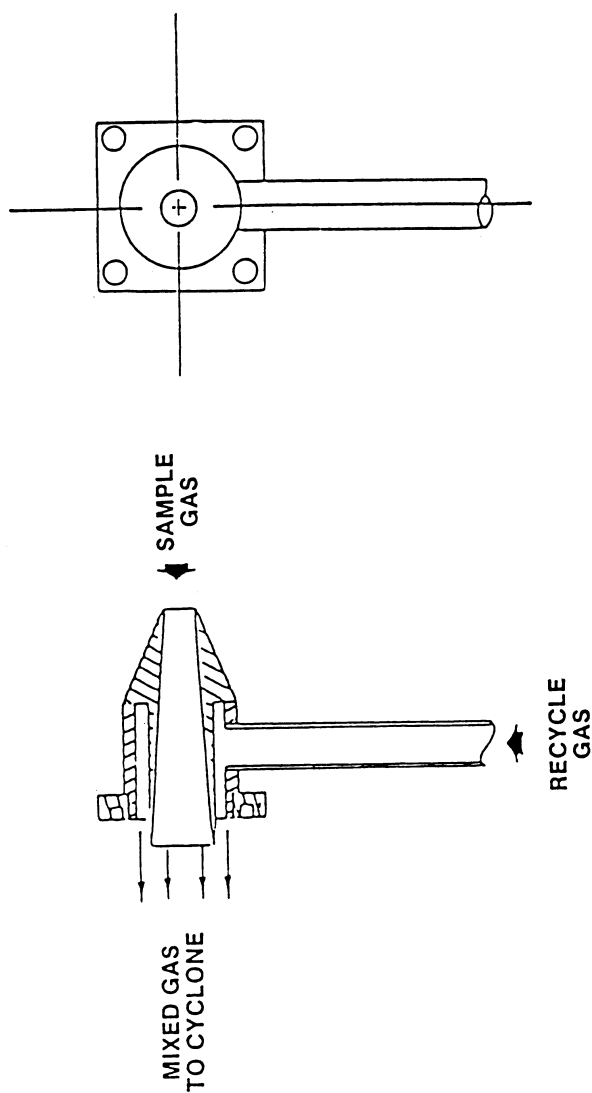


Figure 2. Schematic of EGR nozzle assembly.

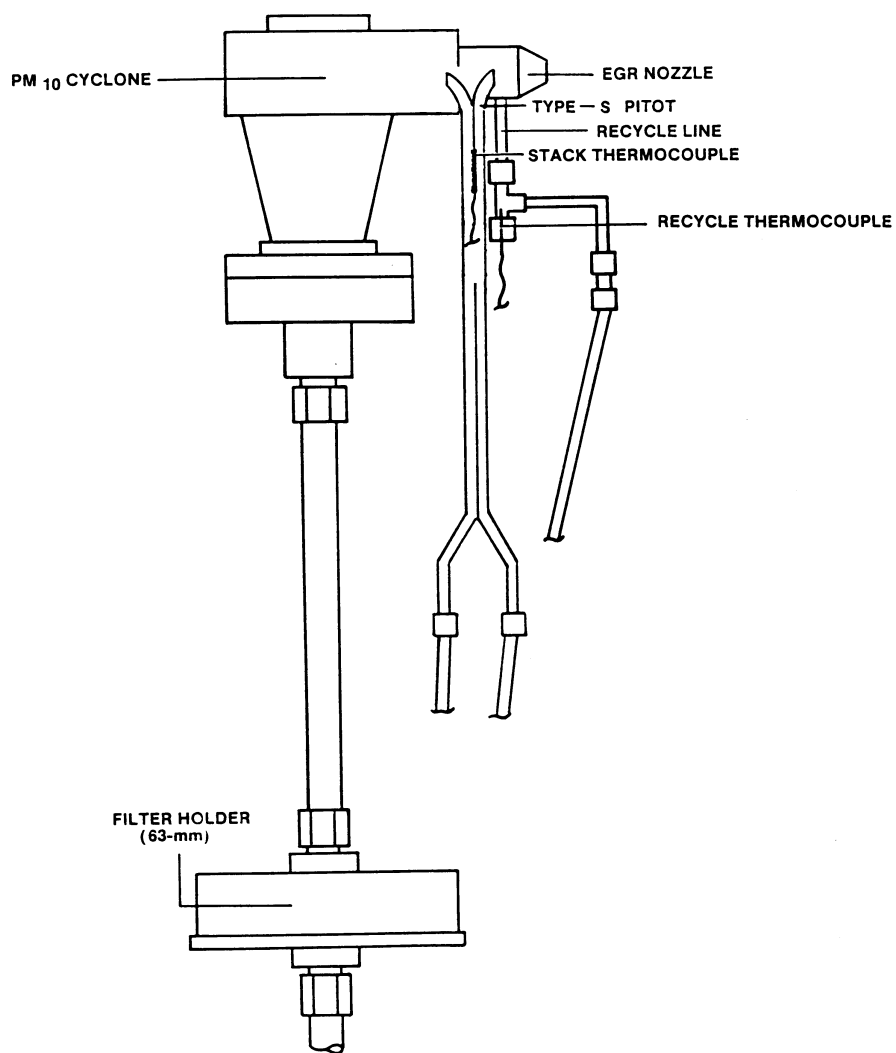


Figure 3. EGR PM₁₀ cyclone sampling device.

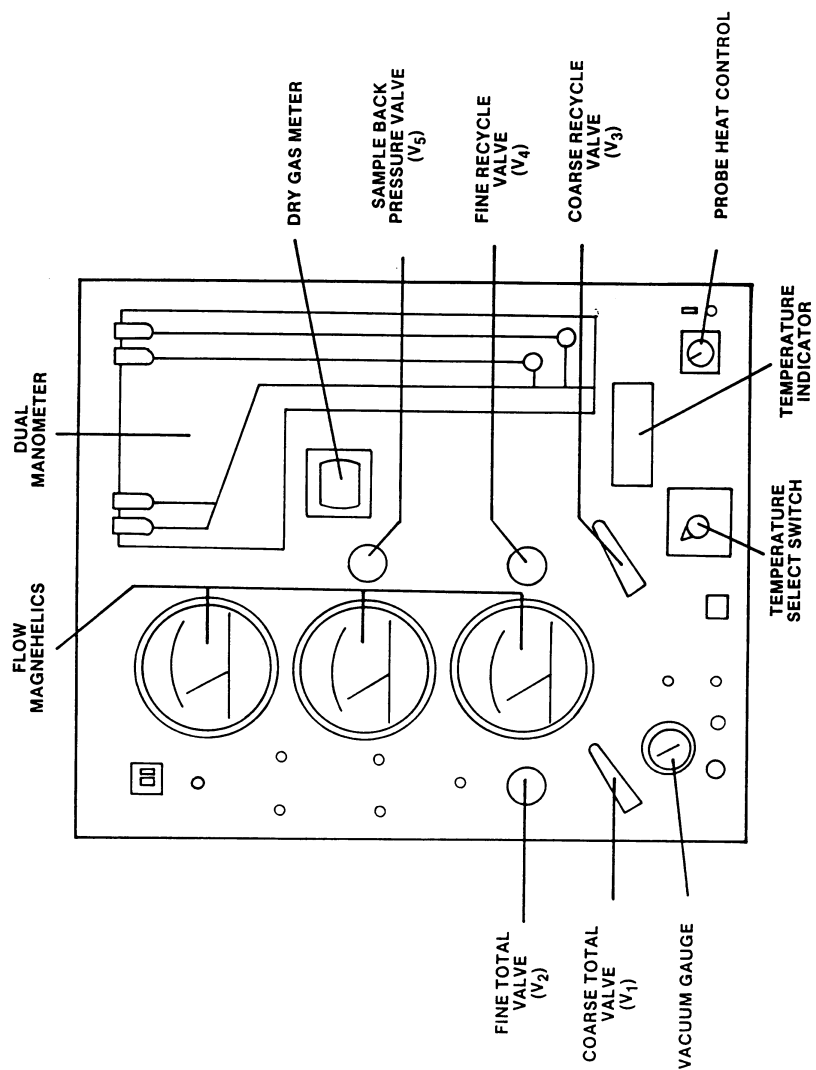


Figure 4. Example EGR control module (front view) showing principle components.

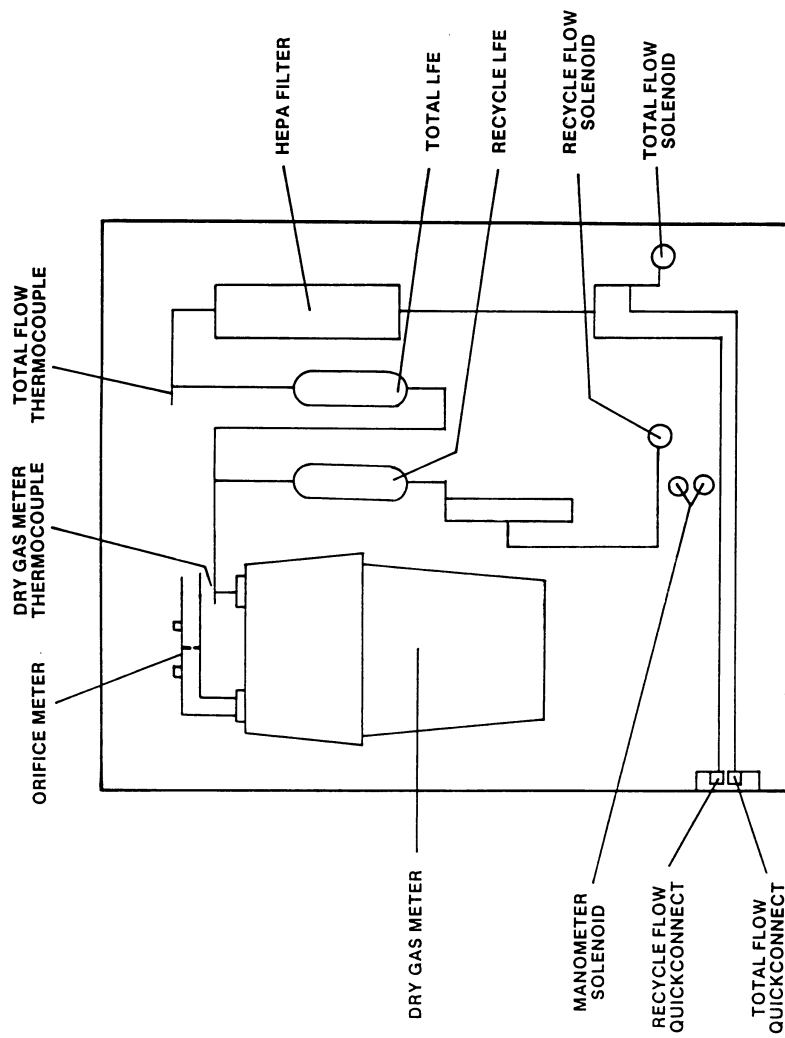


Figure 5. Example EGR control module (rear view) showing principle components.

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EXAMPLE EMISSION GAS RECYCLE
SETUP SHEET

VERSION 3.1 MAY 1986

TEST I.D.: SAMPLE SETUP

RUN DATE: 11/24/86

LOCATION: SOURCE SIM

OPERATOR(S): RH JB

NOZZLE DIAMETER (IN): .25

STACK CONDITIONS:

AVERAGE TEMPERATURE (F): 200.0

AVERAGE VELOCITY (FT/SEC): 15.0

AMBIENT PRESSURE (IN HG): 29.92

STACK PRESSURE (IN H₂O): .10

GAS COMPOSITION:

H₂=10.0%.....MD=28.84O₂=20.9%MW=27.75CO₂=0%.....(LB/LB MOLE)

TARGET PRESSURE DROPS

	TEMPERATURE (F)							
DP(PTO) ..	150	161	172	183	194	206	217	228
0.026	SAMPLE .49	.49	.49	.48	.47	.46	.45	.45
	TOTAL 1.90	1.90	1.91	1.92	1.92	1.92	1.92	1.93
	RECYCLE 2.89	2.92	2.94	2.97	3.00	3.02	3.02	3.05
	% RCL 61%	61%	62%	62%	63%	63%	63%	63%
.031 .....	.58	.56	.55	.55	.55	.54	.53	.52
	1.88	1.89	1.89	1.90	1.91	1.91	1.91	1.92
	2.71	2.74	2.77	2.80	2.82	2.85	2.88	2.90
	57%	57%	58%	58%	59%	59%	60%	60%
.035 .....	.67	.65	.64	.63	.62	.61	.670	.59
	1.88	1.88	1.89	1.89	1.90	1.90	1.91	1.91
	2.57	2.60	2.63	2.66	2.69	2.72	2.74	2.74
	54%	55%	55%	56%	56%	57%	57%	57%
.039 .....	.75	.74	.72	.71	.70	.69	.67	.66
	1.87	1.88	1.88	1.89	1.89	1.90	1.90	1.91
	2.44	2.47	2.50	2.53	2.56	2.59	2.62	2.65
	51%	52%	52%	53%	53%	54%	54%	55%

Figure 6. Example EGR setup sheet.

Barometric pressure, P _{bar} , in. Hg.	=	_____	ΔH@, in. H ₂ O	=	_____
Stack static pressure, P _g , in. H ₂ O.	=	_____	Molecular weight of stack gas, dry basis:		
Average stack temperature, t _s , °F.	=	_____	M _d =0.44		
Meter temperature, t _m , °F.	=	_____	(%CO ₂)+0.32	=	lb/lb mole
Gas analysis:			(%O ₂)+0.28		
%CO ₂	=	_____	(%N ₂ +%CO)		
%O ₂	=	_____	Molecular weight of stack gas, wet basis:		
%N ₂ +%CO	=	_____	M _w =M _d (1-B _{ws})+18B _{ws} .	=	lb/lb mole
Fraction moisture content, B _{ws} .	=	_____	Absolute stack pressure:		
Calibration data:			P _s =P _{bar} +(P _g /13.6)	=	in. Hg
Nozzle diameter, D _n in.	=	_____			
Pitot coefficient, C _p .	=	_____			

$$K = 846.72 D_n^4 \Delta H @ C_p^2 (1-B_{ws})^2 \frac{M_d (t_m + 460) P_s}{M_w (t_s + 460) P_{bar}} = \underline{\hspace{2cm}}$$

Desired meter orifice pressure (ΔH) for velocity head of stack gas (Δp):

$$\Delta H = K \Delta p = \underline{\hspace{2cm}} \text{ in. H}_2\text{O}$$

Figure 7. Example worksheet 1, meter orifice pressure head calculation.

Barometric pressure, P_{bar}, in. Hg. = _____

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Absolute stack pressure, P _s , in. Hg.	=	_____	Total LFE calibration constant, X _i .	=	_____
Average stack temperature, T _s , °R.	=	_____	Total LFE calibration constant, T _i .	=	_____
Meter temperature, T _m , °R.	=	_____	Absolute pressure upstream of LFE:		
Molecular weight of stack gas, wet basis, M _d lb/lb mole.	=	_____	P _{LFE} =P _{bar} +0.6	=	_____ in. Hg
Pressure upstream of LFE, in. Hg.	=	0.6	Viscosity of gas in total LFE:		
Gas analysis:			μ _{LFE} =152.418+0.2552	=	_____
%O ₂	=	_____	T _m +3.2355×10 ⁻⁵		
Fraction moisture content, B _{ws} .	=	_____	T _m 2+0.53147 (%O ₂).		
Calibration data:			Viscosity of dry stack gas:		
Nozzle diameter, D _n , in	=	_____	μ _d =152.418+0.2552	=	_____
Pitot coefficient, C _p ...	=	_____	T _s +3.2355×10 ⁻⁵		
			T _s 2+0.53147 (%O ₂).		
			Constants:		

$$K_1 = 1.5752 \times 10^{-5} \frac{\mu_{LFE} T_m P_s^{0.7051} \mu_d}{P_{LFE} M_d^{0.2949} T_s^{0.07051}} = \underline{\hspace{2cm}}$$

$$K_2 = 0.1539 \frac{\mu_{LFE} T_m D_n^2 C_p \left[\frac{P_s}{T_s} \right]^{\frac{1}{2}}}{P_{LFE}}$$

$$K_3 = \frac{B_{ws} \mu_d [1 - 0.2949(1 - 18/M_d)] + 74.143 B_{ws} (1 - B_{ws})}{\mu_d - 74.143 B_{ws}} = \underline{\hspace{2cm}}$$

$$A_1 = \frac{K_1}{X_t} - \frac{\mu_{LFE} Y_t}{180.1 X_t} = \underline{\hspace{2cm}}$$

$$B_1 = \frac{K_2 K_3}{(M_w)^{\frac{1}{2}} X_t} = \underline{\hspace{2cm}}$$

Total LFE pressure head:

$$\Delta p_t = A_1 - B_1 (\Delta p)^{\frac{1}{2}} = \underline{\hspace{2cm}} \text{ in. H}_2\text{O}$$

Figure 8. Example worksheet 1, meter orifice pressure head calculation.

Barometric pressure, P _{bar} , in. Hg.	=	_____	Average stack temperature, T _s , °R.	=	_____
Absolute stack pressure, P _s , in. Hg.	=	_____	Meter temperature, T _m , °R.	=	_____
			Molecular weight of stack gas, dry basis, M _d lb/lb mole.	=	_____
			Viscosity of LFE gas, μ _{LFE} , poise.	=	_____
			Absolute pressure upstream of LFE, P _{PLE} , in. Hg.	=	_____
			Calibration data:		
			Nozzle diameter, D _n , in	=	_____
			Pitot coefficient, C _p ...	=	_____
			Recycle LFE calibration constant, X _i	=	_____
			Recycle LFE calibration constant, Y _t	=	_____

$$K_1 = 1.5752 \times 10^{-5} \frac{\mu_{LFE} T_m P_s^{0.7051} \mu_d}{P_{LFE} M_d^{0.2949} T_s^{0.07051}} = \underline{\hspace{2cm}}$$

$$K_2 = 0.1539 \frac{M_{LFE} T_m D_n^2 C_p}{P_{LFE}} \left[\frac{P_s}{T_s} \right]^{\frac{1}{2}}$$

$$K_4 = \frac{\mu_d}{M_w^{0.2051} M_d^{0.2949} (\mu_d - 74.143 B_{ws})} = \text{_____}$$

$$A_2 = \frac{K_1}{X_r} - \frac{\mu_{LFE} Y_r}{180.1 X_r} = \text{_____}$$

$$B_2 = \frac{K_4 K_2}{X_r} = \text{_____}$$

Pressure head for recycle LFE:

$$\Delta P_r = A_2 - B_2 (\Delta p)^{\frac{1}{2}} = \text{_____ in. H}_2\text{O}$$

Figure 9. Example worksheet 3, recycle LFE pressure head.

[illegible]

Figure 10. Example EGR Procedure data sheet.

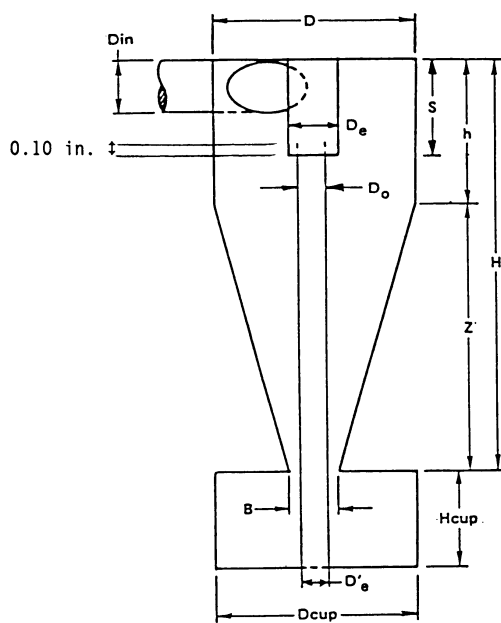
Plant _____
 Date _____
 Run no. _____
 Filter no. _____
 Amount liquid lost during transport _____
 Acetone blank volume, ml _____
 Acetone wash volume, ml (2)——(3) _____
 Acetone blank conc., mg/mg (Equation 5-4,
 Method 5) _____
 Acetone wash blank, mg (Equation 5-5,
 Method 5) _____

Container number	Weight of particulate matter, mg		
	Final weight	Tare weight	Weight gain
1
3
Total
Less acetone blank
Weight of PM ₁₀
2
Less acetone blank

Container number	Weight of particulate matter, mg		
	Final weight	Tare weight	Weight gain
Total particulate weight

Figure 11. EGR method analysis sheet.

Cyclone Interior Dimensions



Dimensions (± 0.02 cm, ± 0.01 in.)												
	D _{in}	D	D _e	B	H	h	Z	S	H _{cup}	D _{cup}	D' _e	D _o
cm	1.27	4.47	1.50	1.88	6.95	2.24	4.71	1.57	2.25	4.45	1.02	1.24
inches	0.50	1.76	0.59	0.74	2.74	0.88	1.85	0.62	0.89	1.75	0.40	0.49

Figure 12. Cyclone design specifications.

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TABLE 1—PERFORMANCE SPECIFICATIONS FOR SOURCE PM₁₀ CYCLONES AND NOZZLE COMBINATIONS

Parameter	Units	Specification
1. Collection efficiency.	Percent	Such that collection efficiency falls within envelope specified by Section 5.7.6 and Figure 13.
2. Cyclone cut size (D ₅₀).	μm	10±1 μm aerodynamic diameter.

TABLE 2—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY

Particle size (μm) ^a	Target gas velocities (m/sec)		
	7±1.0	15±1.5	25±2.5
5±0.5
7±0.5
10±0.5
14±1.0
20±1.0

(a) Mass median aerodynamic diameter.

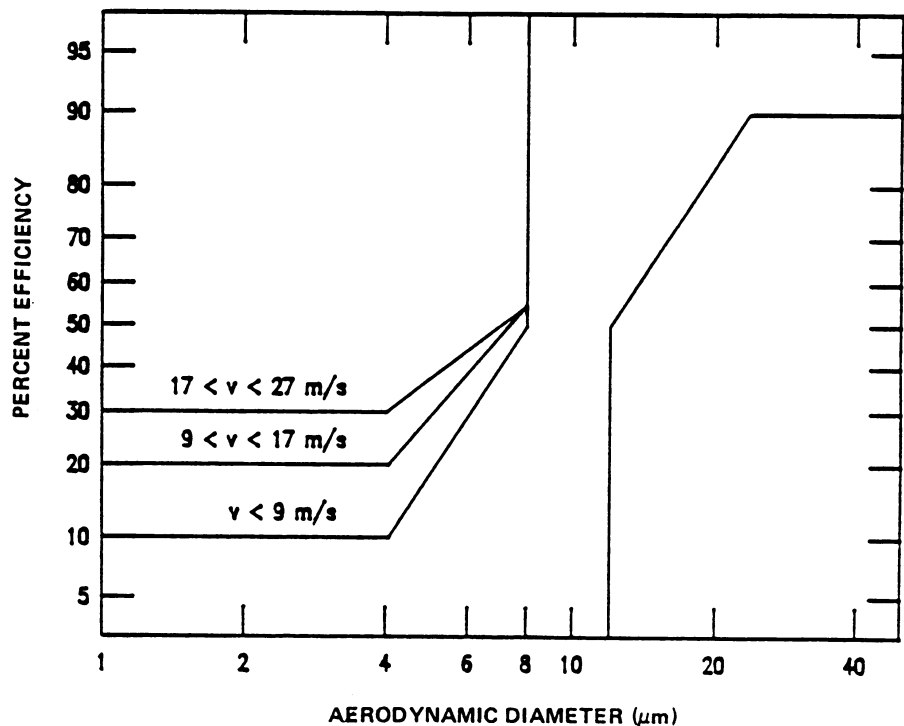


Figure 13. Efficiency envelope for the PM₁₀ cyclone.

EMISSION GAS RECYCLE, DATA REDUCTION,
VERSION 3.4 MAY 1986

Test ID. Code: Chapel Hill 2.
Test Location: Baghouse Outlet.
Test Site: Chapel Hill.
Test Date: 10/20/86.
Operators(s): JB RH MH.

Entered Run Data

Temperatures:
T(STK) 251.0 F
T(RCL) 259.0 F
T(LFE) 81.0 F
T(DGM) 76.0 F
System Pressures:
DH(ORI) 1.18 INWG
DP(TOT) 1.91 INWG
P(INL) 12.15 INWG

Note: Figure 14. Example inputs and outputs of the EGR reduction program.

1.2 Principle. A gas sample is extracted at a constant flow rate through an in-stack sizing device, which separates PM greater than PM₁₀. Variations from isokinetic sampling conditions are maintained within well-defined limits. The particulate mass is determined gravimetrically after removal of uncombined water.

2.1.3 Filter Holder. 63-mm, stainless steel. An Andersen filter, part number SE274, has been found to be acceptable for the in-stack filter. NOTE: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

2.1.4 Pitot Tube. Same as in Method 5, Section 2.1.3. The pitot lines shall be made of heat resistant tubing and attached to the probe with stainless steel fittings.

2.1.5 Probe Liner. Optional, same as in Method 5, Section 2.1.2.

2.1.6 Differential Pressure Gauge, Condenser, Metering System, Barometer, and Gas Density Determination Equipment. Same as in Method 5, Sections 2.1.4, and 2.1.7 through 2.1.10, respectively.

2.2 Sample Recovery.

2.2.1 Nozzle, Sizing Device, Probe, and Filter Holder Brushes. Nylon bristle brushes with stainless steel wire shafts and handles, properly sized and shaped for cleaning the nozzle, sizing device, probe or probe liner, and filter holders.

2.2.2 Wash Bottles, Glass Sample Storage Containers, Petri Dishes, Graduated Cylinder and Balance, Plastic Storage Containers, Funnel and Rubber Policeman, and Funnel. Same as in Method 5, Sections 2.2.2 through 2.2.8, respectively.

2.3 Analysis. Same as in Method 5, Section 2.3.

3. Reagents

The reagents for sampling, sample recovery, and analysis are the same as that specified in Method 5, Sections 3.1, 3.2, and 3.3, respectively.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation. Same as in Method 5, Section 4.1.1.

4.1.2 Preliminary Determinations. Same as in Method 5, Section 4.1.2, except use the directions on nozzle size selection and sampling time in this method. Use of any nozzle greater than 0.16 in. in diameter requires a sampling port diameter of 6 inches. Also, the required maximum number of traverse points at any location shall be 12.

4.1.2.1 The sizing device must be in-stack or maintained at stack temperature during sampling. The blockage effect of the CSR sampling assembly will be minimal if the cross-sectional area of the sampling assembly is 3 percent or less of the cross-sectional area of the duct. If the cross-sectional area of the assembly is greater than 3 percent of the cross-sectional area of the duct, then either determine the pitot coefficient at sampling conditions or use a standard pitot with a known coefficient in a configuration with the CSR sampling assembly such that flow disturbances are minimized.

4.1.2.2 The setup calculations can be performed by using the following procedures.

4.1.2.2.1 In order to maintain a cut size of 10 μm in the sizing device, the flow rate

through the sizing device must be maintained at a constant, discrete value during the run. If the sizing device is a cyclone that meets the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method to calculate three orifice heads (ΔH): one at the average stack temperature, and the other two at temperatures $\pm 28^\circ\text{C}$ ($\pm 50^\circ\text{F}$) of the average stack temperature. Use ΔH calculated at the average stack temperature as the pressure head for the sample flow rate as long as the stack temperature during the run is within 28°C (50°F) of the average stack temperature. If the stack temperature varies by more than 28°C (50°F), then use the appropriate ΔH .

4.1.2.2.2 If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, use the equations in Figure 4 of this method, except use the procedures in Section 5.3 of this method to determine Q_s , the correct cyclone flow rate for a 10 μm size.

4.1.2.2.3 To select a nozzle, use the equations in Figure 5 of this method to calculate Δp_{\min} and Δp_{\max} for each nozzle at all three temperatures. If the sizing device is a cyclone that does not meet the design specifications in Figure 3 of this method, the example worksheets can be used.

4.1.2.2.4 Correct the Method 2 pitot readings to Method 201A pitot readings by multiplying the Method 2 pitot readings by the square of a ratio of the Method 201A pitot coefficient to the Method 2 pitot coefficient. Select the nozzle for which Δp_{\min} and Δp_{\max} bracket all of the corrected Method 2 pitot readings. If more than one nozzle meets this requirement, select the nozzle giving the greatest symmetry. Note that if the expected pitot reading for one or more points is near a limit for a chosen nozzle, it may be outside the limits at the time of the run.

4.1.2.2.5 Vary the dwell time, or sampling time, at each traverse point proportionately with the point velocity. Use the equations in Figure 6 of this method to calculate the dwell time at the first point and at each subsequent point. It is recommended that the number of minutes sampled at each point be rounded to the nearest 15 seconds.

4.1.3 Preparation of Collection Train. Same as in Method 5, Section 4.1.3, except omit directions about a glass cyclone.

4.1.4 Leak-Check Procedure. The sizing device is removed before the post-test leak-check to prevent any disturbance of the collected sample prior to analysis.

4.1.4.1 Pretest Leak-Check. A pretest leak-check of the entire sampling train, including the sizing device, is required. Use the leak-check procedure in Method 5, Section 4.1.4.1 to conduct a pretest leak-check.

4.1.4.2 Leak-Checks During Sample Run. Same as in Method 5, Section 4.1.4.1.

4.1.4.3 **Post-Test Leak-Check.** A leak-check is required at the conclusion of each sampling run. Remove the cyclone before the leak-check to prevent the vacuum created by the cooling of the probe from disturbing the collected sample and use the procedure in Method 5, Section 4.1.4.3 to conduct a post-test leak-check.

4.1.5 **Method 201A Train Operation.** Same as in Method 5, Section 4.1.5, except use the procedures in this section for isokinetic sampling and flow rate adjustment. Maintain the flow rate calculated in Section 4.1.2.2.1 of this method throughout the run provided the stack temperature is within 28 °C (50 °F) of the temperature used to calculate ΔH . If stack temperatures vary by more than 28 °C (50 °F), use the appropriate ΔH value calculated in Section 4.1.2.2.1 of this method. Calculate the dwell time at each traverse point as in Figure 6 of this method.

4.2 **Sample Recovery.** If a cascade impactor is used, use the manufacturer's recommended procedures for sample recovery. If a cyclone is used, use the same sample recovery as that in Method 5, Section 4.2, except an increased number of sample recovery containers is required.

4.2.1 **Container Number 1 (In-Stack Filter).** The recovery shall be the same as that for Container Number 1 in Method 5, Section 4.2.

4.2.3 **Container Number 2 (Cyclone or Large PM Catch).** This step is optional. The anisokinetic error for the cyclone PM is theoretically larger than the error for the PM₁₀ catch. Therefore, adding all the fractions to get a total PM catch is not as accurate as Method 5 or Method 201. Disassemble the cyclone and remove the nozzle to recover the large PM catch. Quantitatively recover the PM from the interior surfaces of the nozzle and cyclone, excluding the "turn around" cup and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.4 **Container Number 3 (PM₁₀).** Quantitatively recover the PM from all of the surfaces from the cyclone exit to the front half of the in-stack filter holder, including the "turn around" cup inside the cyclone and the interior surfaces of the exit tube. The recovery shall be the same as that for Container Number 2 in Method 5, Section 4.2.

4.2.6 **Container Number 4 (Silica Gel).** The recovery shall be the same as that for Container Number 3 in Method 5, Section 4.2.

4.2.7 **Impinger Water.** Same as in Method 5, Section 4.2, under "Impinger Water."

4.3 **Analysis.** Same as in Method 5, Section 4.3, except handle Method 201A Container Number 1 like Container Number 1, Method 201A Container Numbers 2 and 3 like Container Number 2, and Method 201A Container Number 4 like Container Number 3. Use Figure 7 of this method to record the weights of PM collected. Use Figure 5-3 in Method 5,

Section 4.3, to record the volume of water collected.

4.4 **Quality Control Procedures.** Same as in Method 5, Section 4.4.

4.5 **PM₁₀ Emission Calculation and Acceptability of Results.** Use the procedures in section 6 to calculate PM₁₀ emissions and the criteria in section 6.3.5 to determine the acceptability of the results.

5. Calibration

Maintain an accurate laboratory log of all calibrations.

5.1 **Probe Nozzle, Pitot Tube, Metering System, Probe Heater Calibration, Temperature Gauges, Leak-check of Metering System, and Barometer.** Same as in Method 5, Section 5.1 through 5.7, respectively.

5.2 **Probe Cyclone and Nozzle Combinations.** The probe cyclone and nozzle combinations need not be calibrated if both meet design specifications in Figures 2 and 3 of this method. If the nozzles do not meet design specifications, then test the cyclone and nozzle combinations for conformity with performance specifications (PS's) in Table 1 of this method. If the cyclone does not meet design specifications, then the cyclone and nozzle combination shall conform to the PS's and calibrate the cyclone to determine the relationship between flow rate, gas viscosity, and gas density. Use the procedures in Section 5.2 of this method to conduct PS tests and the procedures in Section 5.3 of this method to calibrate the cyclone. The purpose of the PS tests are to conform that the cyclone and nozzle combination has the desired sharpness of cut. Conduct the PS tests in a wind tunnel described in Section 5.2.1 of this method and particle generation system described in Section 5.2.2 of this method. Use five particle sizes and three wind velocities as listed in Table 2 of this method. A minimum of three replicate measurements of collection efficiency shall be performed for each of the 15 conditions listed, for a minimum of 45 measurements.

5.2.1 **Wind Tunnel.** Perform the calibration and PS tests in a wind tunnel (or equivalent test apparatus) capable of establishing and maintaining the required gas stream velocities within 10 percent.

5.2.2 **Particle Generation System.** The particle generation system shall be capable of producing solid monodispersed dye particles with the mass median aerodynamic diameters specified in Table 2 of this method. Perform the particle size distribution verification on an integrated sample obtained during the sampling period of each test. An acceptable alternative is to verify the size distribution of samples obtained before and after each test, with both samples required to meet the diameter and monodispersity requirements for an acceptable test run.

5.2.2.1 Establish the size of the solid dye particles delivered to the test section of the wind tunnel by using the operating parameters of the particle generation system, and verify them during the tests by microscopic examination of samples of the particles collected on a membrane filter. The particle size, as established by the operating parameters of the generation system, shall be within the tolerance specified in Table 2 of this method. The precision of the particle size verification technique shall be at least ± 0.5 μm , and particle size determined by the verification technique shall not differ by more than 10 percent from that established by the operating parameters of the particle generation system.

5.2.2.2 Certify the monodispersity of the particles for each test either by microscopic inspection of collected particles on filters or by other suitable monitoring techniques such as an optical particle counter followed by a multichannel pulse height analyzer. If the proportion of multiplets and satellites in an aerosol exceeds 10 percent by mass, the particle generation system is unacceptable for the purpose of this test. Multiplets are particles that are agglomerated, and satellites are particles that are smaller than the specified size range.

5.2.3 Schematic Drawings. Schematic drawings of the wind tunnel and blower system and other information showing complete procedural details of the test atmosphere generation, verification, and delivery techniques shall be furnished with calibration data to the reviewing agency.

5.2.4 Flow Measurements. Measure the cyclone air flow rates with a dry gas meter and

a stopwatch, or a calibrated orifice system capable of measuring flow rates to within 2 percent.

5.2.5 Performance Specification Procedure. Establish test particle generator operation and verify particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements may be made at this time.

5.2.5.1 The cyclone cut size, or D_{50} , of a cyclone is defined here as the particle size having a 50 percent probability of penetration. Determine the cyclone flow rate at which D_{50} is 10 μm . A suggested procedure is to vary the cyclone flow rate while keeping a constant particle size of 10 μm . Measure the PM collected in the cyclone (m_c), the exit tube (m_t), and the filter (m_f). Calculate cyclone efficiency (E_c) for each flow rate as follows:

$$E_c = \frac{m_c}{(m_c + m_t + m_f)} \times 100$$

5.2.5.2. Do three replicates and calculate the average cyclone efficiency [$E_{c(\text{avg})}$] as follows:

$$E_{c(\text{avg})} = (E_1 + E_2 + E_3)/3$$

Where E_1 , E_2 , and E_3 are replicate measurements of E_c .

5.2.5.3 Calculate the standard deviation (σ) for the replicate measurements of E_c as follows:

$$\sigma = \left[\frac{(E_1^2 + E_2^2 + E_3^2) - \frac{(E_1 + E_2 + E_3)^2}{3}}{2} \right]^{\frac{1}{2}}$$

If σ exceeds 0.10, repeat the replicated runs.

5.2.5.4 Measure the overall efficiency of the cyclone and nozzle, E_o , at the particle sizes and nominal gas velocities in Table 2 of this method using the following procedure.

5.2.5.5 Set the air velocity and particle size from one of the conditions in Table 2 of this method. Establish isokinetic sampling conditions and the correct flow rate in the cyclone (obtained by procedures in this section) such that the D_{50} is 10 μm . Sample long enough to obtain ± 5 percent precision on total collected mass as determined by the precision and the sensitivity of measuring technique. Deter-

mine separately the nozzle catch (m_n), cyclone catch (m_c), cyclone exit tube (M_t), and collection filter catch (m_f) for each particle size and nominal gas velocity in Table 2 of this method. Calculate overall efficiency (E_o) as follows:

$$E_o = \frac{(m_n + m_c)}{(m_n + m_c + m_t + m_f)} \times 100$$

5.2.5.6 Do three replicates for each combination of gas velocity and particle size in Table 2 of this method. Use the equation

below to calculate the average overall efficiency $[E_{o(avg)}]$ for each combination following the procedures described in this section for determining efficiency.

$$E_{o(avg)} = (E_1 + E_2 + E_3) / 3$$

Where E_1 , E_2 , and E_3 are replicate measurements of E_o .

5.2.5.7 Use the formula in Section 5.2.5.3 to calculate σ for the replicate measurements. If σ exceeds 0.10 or if the particle sizes and nominal gas velocities are not within the limits specified in Table 2 of this method, repeat the replicate runs.

5.2.6 Criteria for Acceptance. For each of the three gas stream velocities, plot the $E_{o(avg)}$ as a function of particle size on Figure 8 of this method. Draw smooth curves through all particle sizes. $E_{o(avg)}$ shall be within the banded region for all sizes, and the $E_{c(avg)}$ shall be 50 ± 0.5 percent at $10 \mu\text{m}$.

5.3 Cyclone Calibration Procedure. The purpose of this procedure is to develop the relationship between flow rate, gas viscosity, gas density, and D_{50} .

5.3.1 Calculate Cyclone Flow Rate. Determine flow rates and D_{50} 's for three different particle sizes between $5 \mu\text{m}$ and $15 \mu\text{m}$, one of which shall be $10 \mu\text{m}$. All sizes must be determined within $0.5 \mu\text{m}$. For each size, use a different temperature within 60°C (108°F) of the temperature at which the cyclone is to be used and conduct triplicate runs. A sug-

gested procedure is to keep the particle size constant and vary the flow rate.

5.3.1.1 On log-log graph paper, plot the Reynolds number (Re) on the abscissa, and the square root of the Stokes 50 number $[(Stk_{50})^{1/2}]$ on the ordinate for each temperature. Use the following equations to compute both values:

$$Re = \frac{4 \rho Q_{cyc}}{d_{cyc} \pi \mu_s}$$

$$(Stk_{50})^{1/2} = \left[\frac{4 Q_{cyc} (D_{50})^2}{(9 \pi \mu_s)^3 (d_{cyc})^3} \right]^{1/2}$$

where:

Q_{cyc} = Cyclone flow rate, cm^3/sec .

ρ = Gas density, g/cm^3 .

d_{cyc} = Diameter of cyclone inlet, cm .

μ_s = Viscosity of stack gas, micropoise.

D_{50} = Aerodynamic diameter of a particle having a 50 percent probability of penetration, cm .

5.3.1.2 Use a linear regression analysis to determine the slope (m) and the Y-intercept (b). Use the following formula to determine Q , the cyclone flow rate required for a cut size of $10 \mu\text{m}$.

$$Q_s = \frac{\pi \mu_s}{4} [(3000)(K_1) - b]^{-(0.5-m)} \left[\frac{T_s}{M_w P_s} \right]^{m/(m-0.5)} d^{(m-1.5)/(m-0.5)}$$

where:

m = Slope of the calibration line.

b = y-intercept of the calibration line.

Q_s = Cyclone flow rate for a cut size of $10 \mu\text{m}$, cm^3/sec .

d = Diameter of nozzle, cm .

T_s = Stack gas temperature, $^\circ\text{R}$.

P_s = Absolute stack pressure, in. Hg .

M_w = Wet molecular weight of the stack gas, $\text{lb}/\text{lb-mole}$.

$K_1 = 4.077 \times 10^{-3}$.

5.3.1.3 Refer to the Method 201A operators manual, entitled *Application Guide for Source PM_{10} Measurement with Constant Sampling Rate*, for directions in the use of this equation for Q in the setup calculations.

5.4 Cascade Impactor. The purpose of calibrating a cascade impactor is to determine the empirical constant (STK_{50}), which is specific to the impactor and which permits the accurate determination of the cut size of the impactor stages at field conditions. It is not necessary to calibrate each individual im-

pactor. Once an impactor has been calibrated, the calibration data can be applied to other impactors of identical design.

5.4.1 Wind Tunnel. Same as in Section 5.2.1 of this method.

5.4.2 Particle Generation System. Same as in Section 5.2.2 of this method.

5.4.3 Hardware Configuration for Calibrations. An impaction stage constrains an aerosol to form circular or rectangular jets, which are directed toward a suitable substrate where the larger aerosol particles are collected. For calibration purposes, three stages of the cascade impactor shall be discussed and designated calibration stages 1, 2, and 3. The first calibration stage consists of the collection substrate of an impaction stage and all upstream surfaces up to and including the nozzle. This may include other preceding impactor stages. The second and

third calibration stages consist of each respective collection substrate and all upstream surfaces up to but excluding the collection substrate of the preceding calibration stage. This may include intervening impactor stages which are not designated as calibration stages. The cut size, or D_{50} , of the adjacent calibration stages shall differ by a factor of not less than 1.5 and not more than 2.0. For example, if the first calibration stage has a D_{50} of 12 μm , then the D_{50} of the downstream stage shall be between 6 and 8 μm .

5.4.3.1 It is expected, but not necessary, that the complete hardware assembly will be used in each of the sampling runs of the calibration and performance determinations. Only the first calibration stage must be tested under isokinetic sampling conditions. The second and third calibration stages must be calibrated with the collection substrate of the preceding calibration stage in place, so that gas flow patterns existing in field operation will be simulated.

5.4.3.2 Each of the PM_{10} stages should be calibrated with the type of collection substrate, viscid material (such as grease) or glass fiber, used in PM_{10} measurements. Note that most materials used as substrates at elevated temperatures are not viscid at normal laboratory conditions. The substrate material used for calibrations should minimize particle bounce, yet be viscous enough to withstand erosion or deformation by the impactor jets and not interfere with the procedure for measuring the collected PM.

5.4.4 Calibration Procedure. Establish test particle generator operation and verify particle size microscopically. If monodispersity is to be verified by measurements at the beginning and the end of the run rather than by an integrated sample, these measurements shall be made at this time. Measure in triplicate the PM collected by the calibration stage (m) and the PM on all surfaces downstream of the respective calibration stage (m') for all of the flow rates and particle size combinations shown in Table 2 of this method. Techniques of mass measurement may include the use of a dye and spectrophotometer. Particles on the upstream side of a jet plate shall be included with the substrate downstream, except agglomerates of particles, which shall be included with the preceding or upstream substrate. Use the following formula to calculate the collection efficiency (E) for each stage.

5.4.4.1 Use the formula in Section 5.2.5.3 of this method to calculate the standard deviation (σ) for the replicate measurements. If σ exceeds 0.10, repeat the replicate runs.

5.4.4.2 Use the following formula to calculate the average collection efficiency (E_{avg}) for each set of replicate measurements.

$$E_{\text{avg}} = (E_1 + E_2 + E_3) / 3$$

where E_1 , E_2 , and E_3 are replicate measurements of E.

5.4.4.3 Use the following formula to calculate Stk for each E_{avg} .

$$\text{Stk} = \frac{D^2 Q}{9 \mu A d_j}$$

where:

D = Aerodynamic diameter of the test particle, cm (g/cm^3)^{1/2}.

Q = Gas flow rate through the calibration stage at inlet conditions, cm^3/sec .

μ = Gas viscosity, micropoise.

A = Total cross-sectional area of the jets of the calibration stage, cm^2 .

d_j = Diameter of one jet of the calibration stage, cm.

5.4.4.4 Determine Stk_{50} for each calibration stage by plotting E_{avg} versus Stk on log-log paper. Stk_{50} is the Stk number at 50 percent efficiency. Note that particle bounce can cause efficiency to decrease at high values of Stk. Thus, 50 percent efficiency can occur at multiple values of Stk. The calibration data should clearly indicate the value of Stk_{50} for minimum particle bounce. Impactor efficiency versus Stk with minimal particle bounce is characterized by a monotonically increasing function with constant or increasing slope with increasing Stk.

5.4.4.5 The Stk_{50} of the first calibration stage can potentially decrease with decreasing nozzle size. Therefore, calibrations should be performed with enough nozzle sizes to provide a measured value within 25 percent of any nozzle size used in PM_{10} measurements.

5.4.5 Criteria For Acceptance. Plot E_{avg} for the first calibration stage versus the square root of the ratio of Stk to Stk_{50} on Figure 9 of this method. Draw a smooth curve through all of the points. The curve shall be within the banded region.

6. Calculations

Calculations are as specified in Method 5, sections 6.3 through 6.7, and 6.9 through 6.11, with the addition of the following:

6.1 Nomenclature.

B_{ws} = Moisture fraction of stack, by volume, dimensionless.

C_1 = Viscosity constant, 51.12 micropoise for $^{\circ}\text{K}$ (51.05 micropoise for $^{\circ}\text{R}$).

C_2 = Viscosity constant, 0.372 micropoise/ $^{\circ}\text{K}$ (0.207 micropoise/ $^{\circ}\text{R}$).

C_3 = Viscosity constant, 1.05×10^{-4} micropoise/ $^{\circ}\text{K}^2$ (3.24×10^{-5} micropoise/ $^{\circ}\text{R}^2$).

C_4 = Viscosity constant, 53.147 micropoise/fraction O_2 .

C_5 = Viscosity constant, 74.143 micropoise/fraction H_2O .

D_{50} = Diameter of particles having a 50 percent probability of penetration, μm .

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f_o =Stack gas fraction O₂, by volume, dry basis.

K_1 =0.3858 °K/mm Hg (17.64 °R/in. Hg).

M_w =Wet molecular weight of stack gas, g/g-mole (lb/lb-mole).

M_d =Dry molecular weight of stack gas, g/g-mole (lb/lb-mole).

P_{bar} =Barometric pressure at sampling site, mm Hg (in. Hg).

P_s =Absolute stack pressure, mm Hg (in. Hg).

Q_s =Total cyclone flow rate at wet cyclone conditions, m³/min (ft³/min).

$Q_{s(std)}$ =Total cyclone flow rate at standard conditions, dscm/min (scf/min).

T_m =Average absolute temperature of dry meter, °K (°R).

T_s =Average absolute stack gas temperature, °K (°R).

$V_{w(std)}$ =Volume of water vapor in gas sample (standard conditions), scm (scf).

θ =Total sampling time, min.

μ_s =Viscosity of stack gas, micropoise.

6.2 Analysis of Cascade Impactor Data. Use the manufacturer's recommended procedures to analyze data from cascade impactors.

6.3 Analysis of Cyclone Data. Use the following procedures to analyze data from a single stage cyclone.

6.3.1 PM₁₀ Weight. Determine the PM catch in the PM₁₀ range from the sum of the weights obtained from Container Numbers 1 and 3 less the acetone blank.

6.3.2 Total PM Weight (optional). Determine the PM catch for greater than PM₁₀ from the weight obtained from Container Number 2 less the acetone blank, and add it to the PM₁₀ weight.

6.3.3 PM₁₀ Fraction. Determine the PM₁₀ fraction of the total particulate weight by dividing the PM₁₀ particulate weight by the total particulate weight.

6.3.4 Aerodynamic Cut Size. Calculate the stack gas viscosity as follows:

$$\mu_s = C_1 + C_2 T_s + C_3 T_s^2 + C_4 f_{O_2} - C_5 B_{ws}$$

6.3.4.1 The PM₁₀ flow rate, at actual cyclone conditions, is calculated as follows:

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$$Q_s = \frac{T_s}{K_1 P_s} \left[Q_{s(std)} + \frac{V_{w(std)}}{\theta} \right]$$

6.3.4.2 Calculate the molecular weight on a wet basis of the stack gas as follows:

$$M_w = M_d(1 - B_{ws}) + 18.0(B_{ws})$$

6.3.4.3 Calculate the actual D₅₀ of the cyclone for the given conditions as follows:

$$D_{50} = \beta_1 \left[\frac{T_s}{M_w P_s} \right]^{0.2091} \left[\frac{\mu_s}{Q_s} \right]^{0.7091}$$

where β_1 =0.027754 for metric units (0.15625 for English units).

6.3.5 Acceptable Results. The results are acceptable if two conditions are met. The first is that $9.0 \mu m \leq D_{50} \leq 11.0 \mu m$. The second is that no sampling points are outside Δp_{min} and Δp_{max} , or that 80 percent $\leq I \leq 120$ percent and no more than one sampling point is outside Δp_{min} and Δp_{max} . If D₅₀ is less than 9.0 μm , reject the results and repeat the test.

7. Bibliography

1. Same as Bibliography in Method 5.
2. McCain, J.D., J.W. Ragland, and A.D. Williamson. Recommended Methodology for the Determination of Particle Size Distributions in Ducted Sources, Final Report. Prepared for the California Air Resources Board by Southern Research Institute. May 1986.
3. Farthing, W.E., S.S. Dawes, A.D. Williamson, J.D. McCain, R.S. Martin, and J.W. Ragland. Development of Sampling Methods for Source PM₁₀ Emissions. Southern Research Institute for the Environmental Protection Agency. April 1989. NTIS PB 89 190375, EPA/600/3-88-056.
4. *Application Guide for Source PM₁₀ Measurement with Constant Sampling Rate*, EPA/600/3-88-057.

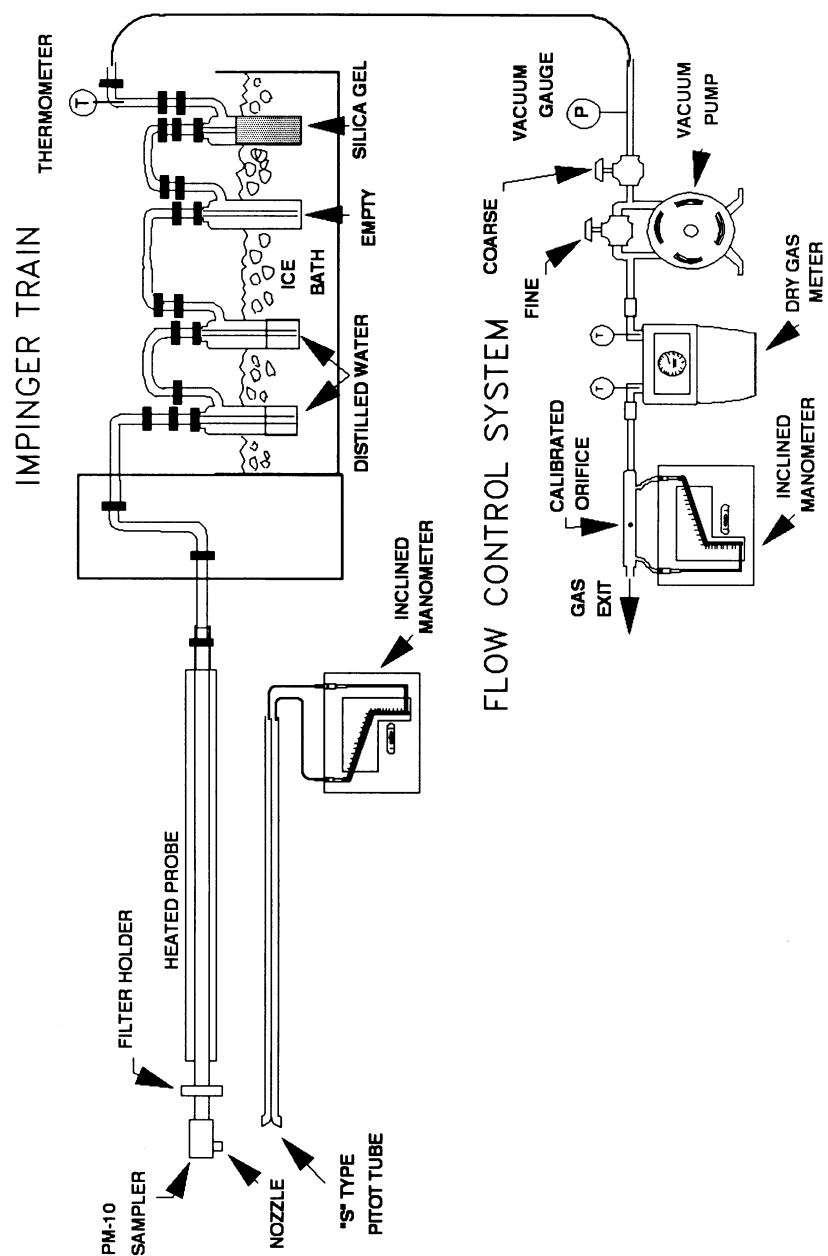
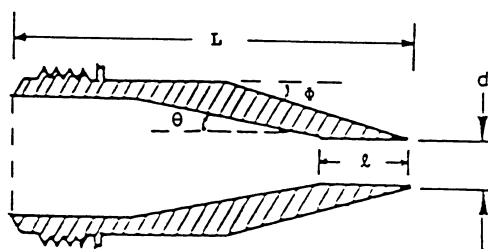


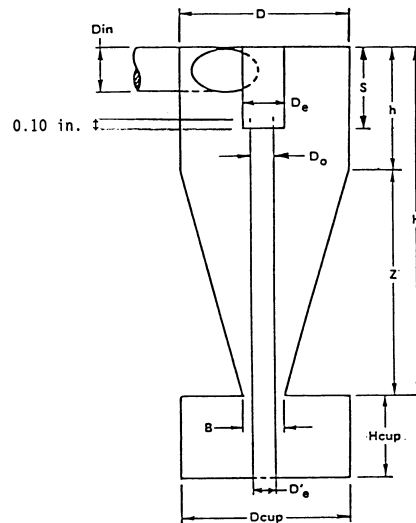
Figure 1. CSR Sampling Train



Nozzle Diameter (inches)	Cone Angle, θ (degrees)	Outside taper, ϕ (degrees)	Straight inlet length, l (inches)	Total Length L (inches)
0.136	4	15	<0.05	2.653 ± 0.05
0.150	4	15	<0.05	2.553 ± 0.05
0.164	5	15	<0.05	1.970 ± 0.05
0.180	6	15	<0.05	1.572 ± 0.05
0.197	6	15	<0.05	1.491 ± 0.05
0.215	6	15	<0.05	1.45 ± 0.05
0.233	6	15	<0.05	1.45 ± 0.05
0.264	5	15	<0.05	1.45 ± 0.05
0.300	4	15	<0.05	1.48 ± 0.05
0.342	4	15	<0.05	1.45 ± 0.05
0.390	3	15	<0.05	1.45 ± 0.05

Figure 2. Nozzle design specifications.

Cyclone Interior Dimensions



	Dimensions (±0.02 cm, ±0.01 in.)											
	Din	D	De	B	H	h	Z	S	Hcup	Dcup	D _e '	D _o
cm	1.27	4.47	1.50	1.88	6.95	2.24	4.71	1.57	2.25	4.45	1.02	1.24
inches	0.50	1.76	0.59	0.74	2.74	0.88	1.85	0.62	0.89	1.75	0.40	0.49

Figure 3. Cyclone design specifications.

Barometric pressure,
 P_{bar} , in. Hg= _____
 Stack static pressure,
 P_s , in. H₂O= _____
 Average stack temperature,
 t_s , °F= _____
 Meter temperature, t_m , °F= _____
 Orifice ΔH_o , in. H₂O= _____
 Gas analysis:
 %CO₂= _____
 %O₂= _____
 %N₂+%CO= _____
 Fraction moisture content,
 B_{ws} = _____

Molecular weight of stack gas, dry basis:
 $M_d = 0.44 (\% \text{CO}_2) + 0.32 (\% \text{O}_2) + 0.28 (\% \text{N}_2 + \% \text{CO}) =$ _____ lb/lb mole
 Molecular weight of stack gas, wet basis:
 $M_w = M_d (1 - B_{ws}) + 18 (B_{ws}) =$ _____ lb/lb mole
 Absolute stack pressure:

$$P_s = P_{\text{bar}} + \frac{P_g}{13.6} = \text{_____ in. Hg}$$

Viscosity of stack gas:
 $\mu_s = 152.418 + 0.2552 t_s + 3.2355 \times 10^{-5} t_s^2 + 0.53147$
 $(\% \text{O}_2) - 74.143 B_{ws} =$ _____ micropoise
 Cyclone flow rate:

$$Q_s = 0.002837 \mu_s \left[\frac{(t_s + 460)}{M_w P_s} \right]^{0.2949} = \text{___ ft}^3/\text{min}$$

Figure 4. Example worksheet 1, cyclone Orifice pressure head (ΔH) needed for cyclone flow rate and ΔH . flow rate:

$$\Delta H = \left[\frac{Q_s (1 - B_{ws}) P_s}{t_s + 460} \right]^2 \frac{t_{m+460} M_d 1.083 \Delta H_{@}}{P_{bar}} = \text{___ in. H}_2\text{O}$$

Calculate ΔH for three temperatures:

t_s , °F			
ΔH , in. H ₂ O			

Stack viscosity, μ_s ,
micropoise = ___

Absolute stack pressure,

P_s , in. Hg = ___

Average stack temperature,

t_s , °F = ___

Meter temperature, t_m , °F = ___

Method 201A pitot coefficient,

C_p = ___

Cyclone flow rate, ft³/min,

Q_s = ___

Method 2 pitot coefficient,

C_p' = ___

Molecular weight of stack gas, wet basis,

M_w = ___

Nozzle diameter, D_n , in. = ___

Nozzle velocity:

$$v_n = \frac{3.056 Q_s}{D_n^2} = \text{___ ft/sec}$$

$$v_{\min} = v_n \left[0.2457 + \left[0.3072 - \frac{0.2603 Q_s^{\frac{1}{2}} \mu_s}{v_n^{1.5}} \right]^{\frac{1}{2}} \right] = \text{___ ft/sec}$$

$$v_{\max} = v_n \left[0.4457 + \left[0.5690 - \frac{0.2603 Q_s^{\frac{1}{2}} \mu_s}{v_n^{1.5}} \right]^{\frac{1}{2}} \right] = \text{___ ft/sec}$$

Maximum and minimum velocities:

Calculate R_{\min}

$$R_{\min} = 0.2457 + 0.3072 - \frac{0.2603 (\sqrt{Q_s}) \mu_s}{v_n^{1.5}} = \text{___}$$

If R_{\min} is less than 0.5, or if an imaginary number occurs when calculating R_{\min} , use

Equation 1 to calculate v_{\min} . Otherwise, use Equation 2.

Eq. 1 $v_{\min} = v_n (0.5) = \text{___ ft/sec}$

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Eq. 2 $v_{\min} = v_n R_{\min} = \text{ft/sec}$
Calculate R_{\max} .

$$R_{\max} = 0.4457 + 0.5690 + \frac{0.2603(\sqrt{Q_s})\mu_s}{v_n 1.5} = \text{ft/sec}$$

If R_{\max} is greater than 1.5, use Equation 3 to calculate v_{\max} . Otherwise, use Equation 4.
Eq. 3 $v_{\max} = v_n (1.5) = \text{ft/sec}$
Eq. 4 $v_{\max} = v_n R_{\max} = \text{ft/sec}$

Figure 5. Example worksheet 2, nozzle selection.
Maximum and minimum velocity head values:

$$\Delta p_{\min} = 1.3686 \times 10^{-4} \frac{P_s M_w (v_{\min})^2}{(t_s + 460) C_p^2} = \text{in. H}_2\text{O}$$

$$\Delta p_{\max} = 1.3686 \times 10^{-4} \frac{P_s M_w (v_{\max})^2}{(t_s + 460) C_p^2} = \text{in. H}_2\text{O}$$

Nozzle No.				
D_n , in. ....	.....	.....	.....	.....
v_n , ft/sec .....	.....	.....	.....	.....
v_{\min} , ft/sec .....	.....	.....	.....	.....
v_{\max} , ft/sec .....	.....	.....	.....	.....

Nozzle No.				
Δp_{\min} , in. H ₂ O .....	.....	.....	.....	.....
Δp_{\max} , in. H ₂ O .....	.....	.....	.....	.....

Velocity traverse data:

$$\Delta p(\text{Method 201A}) = \Delta p(\text{Method 2}) \left[\frac{C_p}{C_{p'}} \right]^2$$

Total run time, minutes = _____
Number of traverse points = _____

$$t_1 = \left[\frac{\Delta p'_1}{\Delta p'_{\text{avg}}} \right]^{\frac{1}{2}} \frac{(\text{Total run time})}{(\text{Number of points})}$$

where:

t_1 = dwell time at first traverse point, minutes.
 $\Delta p'_1$ = the velocity head at the first traverse point (from a previous traverse), in. H₂O.
 $\Delta p'_{\text{avg}}$ = the square of the average square root of the Δp 's (from a previous velocity traverse), in. H₂O.

At subsequent traverse points, measure the velocity Δp and calculate the dwell time by using the following equation:

$$t_n = \frac{t_1}{(\Delta p_1)^{\frac{1}{2}}} (\Delta p_n)^{\frac{1}{2}}, n = 2, 3, \dots, \text{total number of sampling points}$$

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where:

t_n = dwell time at traverse point n, minutes.

Δp_n = measured velocity head at point n, in. H_2O .

Δp_1 = measured velocity head at point 1 in. H_2O .

Figure 6. Example worksheet 3, dwell time.

Point No.	Port							
	Δp	t	Δp	t	Δp	t	Δp	t
1
2
3
4
5
6

Plant _____
 Date _____
 Run no. _____
 Filter no. _____
 Amount of liquid lost during transport _____
 Acetone blank volume, ml _____
 Acetone wash volume, ml (4) _____
 (5) _____
 Acetone blank conc., mg/mg (Equation 5-4, Method 5) _____
 Acetone wash blank, mg (Equation 5-5, Method 5) _____

Container No.	Weight of PM_{10} (mg)		
	Final weight	Tare weight	Weight gain
1
3
Total
Less acetone blank
Weight of PM_{10}

Figure 7. Method 201A analysis sheet.

TABLE 1—PERFORMANCE SPECIFICATIONS FOR SOURCE PM_{10} CYCLONES AND NOZZLE COMBINATIONS

Parameter	Units	Specifications
1. Collection efficiency.	Percent	Such that collection efficiency falls within envelope specified by Section 5.2.6 and Figure 8.
2. Cyclone cut size (D_{50}).	μm	$10 \pm 1 \mu m$ aerodynamic diameter.

TABLE 2—PARTICLE SIZES AND NOMINAL GAS VELOCITIES FOR EFFICIENCY

Particle size (μm) ^a	Target gas velocities (m/sec)		
	7±1.0	15±1.5	25±2.5
5±0.5
7±0.5
10±0.5
14±1.0
20±1.0

(^a) Mass median aerodynamic diameter.

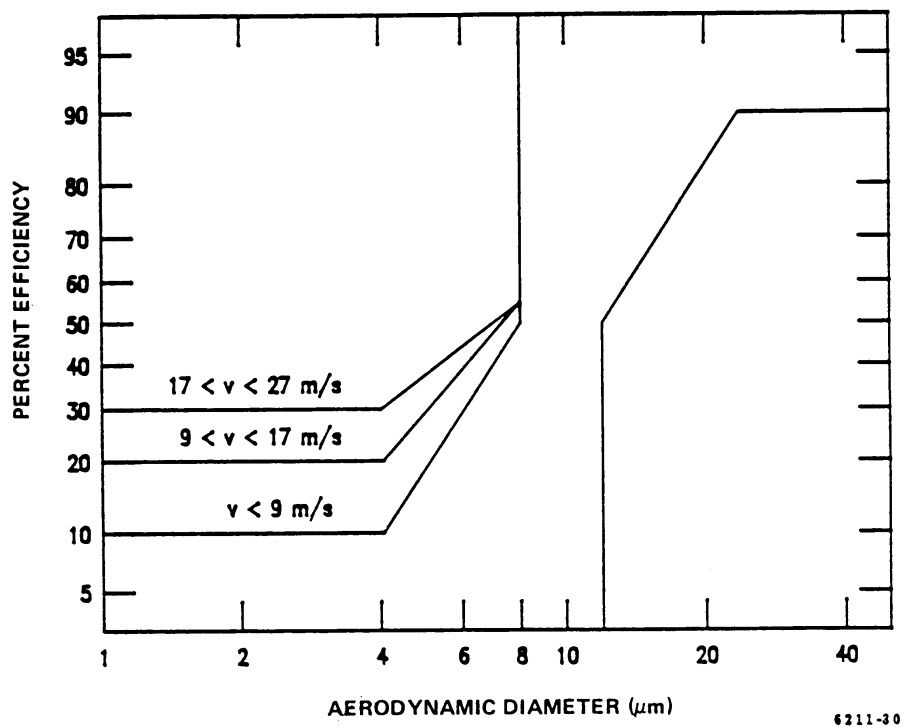
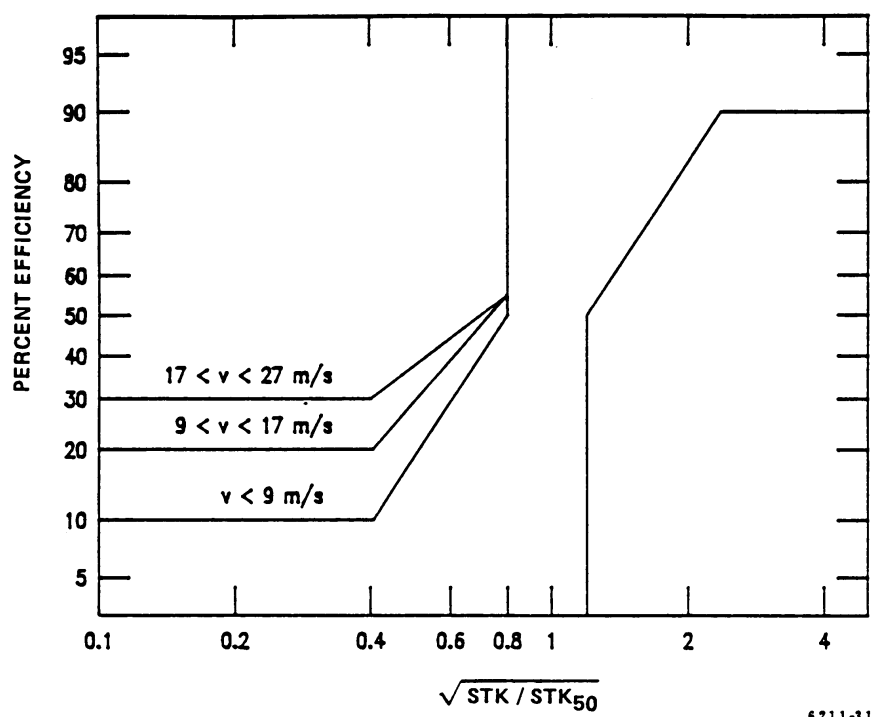


Figure 8. Efficiency envelope for the PM₁₀ cyclone.



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Figure 9. Efficiency envelope for first calibration stage.

METHOD 202—DETERMINATION OF CONDENSIBLE PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. Applicability and Principle

1.1 Applicability.

1.1.1 This method applies to the determination of condensible particulate matter (CPM) emissions from stationary sources. It is intended to represent condensible matter as material that condenses after passing through a filter and as measured by this method (Note: The filter catch can be analyzed according to the appropriate method).

1.1.2 This method may be used in conjunction with Method 201 or 201A if the probes are glass-lined. Using Method 202 in conjunction with Method 201 or 201A, only the impinger train configuration and analysis is addressed by this method. The sample train operation and front end recovery and analysis shall be conducted according to Method 201 or 201A.

1.1.3 This method may also be modified to measure material that condenses at other

temperatures by specifying the filter and probe temperature. A heated Method 5 out-of-stack filter may be used instead of the in-stack filter to determine condensible emissions at wet sources.

1.2 Principle.

1.2.1 The CPM is collected in the impinger portion of a Method 17 (appendix A, 40 CFR part 60) type sampling train. The impinger contents are immediately purged after the run with nitrogen (N_2) to remove dissolved sulfur dioxide (SO_2) gases from the impinger contents. The impinger solution is then extracted with methylene chloride ($MeCl_2$). The organic and aqueous fractions are then taken to dryness and the residues weighed. The total of both fractions represents the CPM.

1.2.2 The potential for low collection efficiency exist at oil-fired boilers. To improve the collection efficiency at these type of sources, an additional filter placed between the second and third impinger is recommended.

2. Precision and Interference

2.1 Precision. The precision based on method development tests at an oil-fired boiler and a catalytic cracker were 11.7 and 4.8 percent, respectively.

2.2 Interference. Ammonia. In sources that use ammonia injection as a control technique for hydrogen chloride (HCl), the ammonia interferes by reacting with HCl in the gas stream to form ammonium chloride (NH₄Cl) which would be measured as CPM. The sample may be analyzed for chloride and the equivalent amount of NH₄Cl can be subtracted from the CPM weight. However, if NH₄Cl is to be counted as CPM, the inorganic fraction should be taken to near dryness (less than 1 ml liquid) in the oven and then allowed to air dry at ambient temperature to prevent any NH₄Cl from vaporizing.

3. Apparatus

3.1 Sampling Train. Same as in Method 17, section 2.1, with the following exceptions noted below (see Figure 202-1). *Note:* Mention of trade names or specific products does not constitute endorsement by EPA.

3.1.1 The probe extension shall be glass-lined or Teflon.

3.1.2 Both the first and second impingers shall be of the Greenburg-Smith design with the standard tip.

3.1.3 All sampling train glassware shall be cleaned prior to the test with soap and tap water, water, and rinsed using tap water, water, acetone, and finally, MeCl₂. It is important to completely remove all silicone grease from areas that will be exposed to the MeCl₂ during sample recovery.

3.2 Sample Recovery. Same as in Method 17, section 2.2, with the following additions:

3.2.1 N₂ Purge Line. Inert tubing and fittings capable of delivering 0 to 28 liters/min of N₂ gas to the impinger train from a standard gas cylinder (see Figure 202-2). Standard 0.95 cm (3/8-inch) plastic tubing and compression fittings in conjunction with an adjustable pressure regulator and needle valve may be used.

3.2.2 Rotameter. Capable of measuring gas flow at 20 liters/min.

3.3 Analysis. The following equipment is necessary in addition to that listed in Method 17, section 2.3:

3.3.1 Separatory Funnel. Glass, 1-liter.

3.3.2 Weighing Tins. 350-ml.

3.3.3 Dry Equipment. Hot plate and oven with temperature control.

3.3.4 Pipets. 5-ml.

3.3.5 Ion Chromatograph. Same as in Method 5F, Section 2.1.6.

4. Reagents

Unless otherwise indicated, all reagents must conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society.

Where such specifications are not available, use the best available grade.

4.1 Sampling. Same as in Method 17, section 3.1, with the addition of deionized distilled water to conform to the American Society for Testing and Materials Specification D 1193-74, Type II and the omission of section 3.1.4.

4.2 Sample Recovery. Same as in Method 17, section 3.2, with the following additions:

4.2.1 N₂ Gas. Zero N₂ gas at delivery pressures high enough to provide a flow of 20 liters/min for 1 hour through the sampling train.

4.2.2 Methylene Chloride, ACS grade. Blanks shall be run prior to use and only methylene chloride with low blank values (0.001 percent) shall be used.

4.2.3 Water. Same as in section 4.1.

4.3 Analysis. Same as in Method 17, section 3.3, with the following additions:

4.3.1 Methylene Chloride. Same as section 4.2.2.

4.3.2 Ammonium Hydroxide. Concentrated (14.8 M) NH₄OH.

4.3.3 Water. Same as in section 4.1.

4.3.4 Phenolphthalein. The pH indicator solution, 0.05 percent in 50 percent alcohol.

5. Procedure

5.1 Sampling. Same as in Method 17, section 4.1, with the following exceptions:

5.1.1 Place 100 ml of water in the first three impingers.

5.1.2 The use of silicone grease in train assembly is not recommended because it is very soluble in MeCl₂ which may result in sample contamination. Teflon tape or similar means may be used to provide leak-free connections between glassware.

5.2 Sample Recovery. Same as in Method 17, section 4.2 with the addition of a post-test N₂ purge and specific changes in handling of individual samples as described below.

5.2.1 Post-test N₂ Purge for Sources Emitting SO₂. (Note: This step is recommended, but is optional. With little or no SO₂ is present in the gas stream, i.e., the pH of the impinger solution is greater than 4.5, purging has been found to be unnecessary.) As soon as possible after the post-test leak check, detach the probe and filter from the impinger train. Leave the ice in the impinger box to prevent removal of moisture during the purge. If necessary, add more ice during the purge to maintain the gas temperature below 20 °C. With no flow of gas through the clean purge line and fittings, attach it to the input of the impinger train (see Figure 202-2). To avoid over- or underpressurizing the impinger array, slowly commence the N₂ gas flow through the line while simultaneously opening the meter box pump valve(s). When using the gas cylinder pressure to push the purge gas through the sample train, adjust the flow rate to 20 liters/min through the rotameter. When pulling the

purge gas through the sample train using the meter box vacuum pump, set the orifice pressure differential to ΔH_0 and maintain an overflow rate through the rotameter of less than 2 liters/min. This will guarantee that the N_2 delivery system is operating at greater than ambient pressure and prevents the possibility of passing ambient air (rather than N_2) through the impingers. Continue the purge under these conditions for 1 hour, checking the rotameter and ΔH value(s) periodically. After 1 hour, simultaneously turn off the delivery and pumping systems.

5.2.2 Sample Handling.

5.2.2.1 Container Nos. 1, 2, and 3. If filter catch is to be determined, as detailed in Method 17, section 4.2.

5.2.2.2 Container No. 4 (Impinger Contents). Measure the liquid in the first three impingers to within 1 ml using a clean graduated cylinder or by weighing it to within 0.5 g using a balance. Record the volume or weight of liquid present to be used to calculate the moisture content of the effluent gas. Quantitatively transfer this liquid into a clean sample bottle (glass or plastic); rinse each impinger and the connecting glassware, including probe extension, twice with water, recover the rinse water, and add it to the same sample bottle. Mark the liquid level on the bottle.

5.2.2.3 Container No. 5 ($MeCl_2$ Rinse). Follow the water rinses of each impinger and the connecting glassware, including the probe extension with two rinses of $MeCl_2$; save the rinse products in a clean, glass sample jar. Mark the liquid level on the jar.

5.2.2.4 Container No. 6 (Water Blank). Once during each field test, place 500 ml of water in a separate sample container.

5.2.2.5 Container No. 7 ($MeCl_2$ Blank). Once during each field test, place in a separate glass sample jar a volume of $MeCl_2$ approximately equivalent to the volume used to conduct the $MeCl_2$ rinse of the impingers.

5.3 Analysis. Record the data required on a sheet such as the one shown in Figure 202-3. Handle each sample container as follows:

5.3.1 Container Nos. 1, 2, and 3. If filter catch is analyzed, as detailed in Method 17, section 4.3.

5.3.2 Container Nos. 4 and 5. Note the level of liquid in the containers and confirm on the analytical data sheet whether leakage occurred during transport. If a noticeable amount of leakage has occurred, either void the sample or use methods, subject to the approval of the Administrator, to correct the final results. Measure the liquid in Container No. 4 either volumetrically to ± 1 ml or gravimetrically to ± 0.5 g. Remove a 5-ml aliquot and set aside for later ion chromatographic (IC) analysis of sulfates. (Note: Do not use this aliquot to determine chlorides since the HCl will be evaporated during the first drying step; Section 8.2 details a procedure for this analysis.)

5.3.2.1 Extraction. Separate the organic fraction of the sample by adding the contents of Container No. 4 ($MeCl_2$) to the contents of Container No. 4 in a 1000-ml separatory funnel. After mixing, allow the aqueous and organic phases to fully separate, and drain off most of the organic/ $MeCl_2$ phase. Then add 75 ml of $MeCl_2$ to the funnel, mix well, and drain off the lower organic phase. Repeat with another 75 ml of $MeCl_2$. This extraction should yield about 250 ml of organic extract. Each time, leave a small amount of the organic/ $MeCl_2$ phase in the separatory funnel ensuring that no water is collected in the organic phase. Place the organic extract in a tared 350-ml weighing tin.

5.3.2.2 Organic Fraction Weight Determination (Organic Phase from Container Nos. 4 and 5). Evaporate the organic extract at room temperature and pressure in a laboratory hood. Following evaporation, desiccate the organic fraction for 24 hours in a desiccator containing anhydrous calcium sulfate. Weigh to a constant weight and report the results to the nearest 0.1 mg.

5.3.2.3 Inorganic Fraction Weight Determination. (Note: If NH_4Cl is to be counted as CPM, the inorganic fraction should be taken to near dryness (less than 1 ml liquid) in the oven and then allow to air dry at ambient temperature. If multiple acid emissions are suspected, the ammonia titration procedure in section 8.1 may be preferred.) Using a hot plate, or equivalent, evaporate the aqueous phase to approximately 50 ml; then, evaporate to dryness in a 105 °C oven. Redisolve the residue in 100 ml of water. Add five drops of phenolphthalein to this solution; then, add concentrated (14.8 M) NH_4OH until the sample turns pink. Any excess NH_4OH will be evaporated during the drying step. Evaporate the sample to dryness in a 105 °C oven, desiccate the sample for 24 hours, weigh to a constant weight, and record the results to the nearest 0.1 mg. (Note: The addition of NH_4OH is recommended, but is optional when little or no SO_2 is present in the gas stream, i.e., when the pH of the impinger solution is greater than 4.5, the addition of NH_4OH is not necessary.)

5.3.2.4 Analysis of Sulfate by IC to Determine Ammonium Ion (NH_4^+) Retained in the Sample. (Note: If NH_4OH is not added, omit this step.) Determine the amount of sulfate in the aliquot taken from Container No. 4 earlier as described in Method 5F (appendix A, 40 CFR part 60). Based on the IC SO_4^{2-} analysis of the aliquot, calculate the correction factor to subtract the NH_4^+ retained in the sample and to add the combined water removed by the acid-base reaction (see section 7.2).

5.3.3 Analysis of Water and $MeCl_2$ Blanks (Container Nos. 6 and 7). Analyze these sample blanks as described above in sections 5.3.2.3 and 5.3.2.2, respectively.

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5.3.4 Analysis of Acetone Blank (Container No. 8). Same as in Method 17, section 4.3.

6. Calibration

Same as in Method 17, section 5, except for the following:

6.1 IC Calibration. Same as Method 5F, section 5.

6.2 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

6.3 Audit Samples. Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing:

Source Test Audit Coordinator (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle, Park, NC 27711

or by calling the Source Test Audit Coordinator (STAC) at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.4 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calculations

Same as in Method 17, section 6, with the following additions:

7.1 Nomenclature. Same as in Method 17, section 6.1 with the following additions.

C_{cpm} =Concentration of the CPM in the stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

C_{SO_4} =Concentration of SO_4^{2-} in the sample, mg/ml.

m_b =Sum of the mass of the water and $MeCl_2$ blanks, mg.

m_c =Mass of the NH_4^+ added to sample to form ammonium sulfate, mg.

m_i =Mass of inorganic CPM matter, mg.

m_o =Mass of organic CPM, mg.

m_r =Mass of dried sample from inorganic fraction, mg.

V_b =Volume of aliquot taken for IC analysis, ml.

V_{ic} =Volume of impinger contents sample, ml.

7.2 Correction for NH_4^+ and H_2O . Calculate the correction factor to subtract the NH_4^+ retained in the sample based on the IC SO_4^{2-} and if desired, add the combined water removed by the acid-base reaction.

$$m_c = KC_{SO_4} V_{ic} \quad \text{Eq. 202-1}$$

=0.1840, when only correcting for NH_4^+ .

7.3 Mass of Inorganic CPM.

$$m_i = m_r \frac{V_{ic}}{V_{ic} - V_b} - m_c \quad \text{Eq. 202-2}$$

7.4

Concentration of CPM.

$$C_{cpm} = \frac{m_o + m_i - m_b}{VM_{std}} \quad \text{Eq. 202-3}$$

8. Alternative Procedures

8.1 Determination of NH_4^+ Retained in Sample by Titration.

8.1.1 An alternative procedure to determine the amount of NH_4^+ added to the inorganic fraction by titration may be used. After dissolving the inorganic residue in 100 ml of water, titrate the solution with 0.1 N $NH_4 OH$ to a pH of 7.0, as indicated by a pH meter. The 0.1 N $NH_4 OH$ is made as follows: Add 7 ml of concentrated (14.8 M) $NH_4 OH$ to 1 liter of water. Standardize against standardized 0.1 N $H_2 SO_4$ and calculate the exact normality using a procedure parallel to that described in section 5.5 of Method 6 (appendix A, 40 CFR part 60). Alternatively, purchase 0.1 N $NH_4 OH$ that has been standardized against a National Institute of Standards and Technology reference material.

8.1.2 Calculate the concentration of SO_4^{2-} in the sample using the following equation.

$$CSO_4 = \frac{48.03 V_t N}{100} \quad \text{Eq. 202-4}$$

where

N = Normality of the $NH_4 OH$, mg/ml.

V_t = Volume of $NH_4 OH$ titrant, ml.

48.03 = mg/meq.

100 = Volume of solution, ml.

8.3.1 Calculate the CPM as described in section 7.

8.2 Analysis of Chlorides by IC. At the conclusion of the final weighing as described in section 5.3.2.3, redissolve the inorganic fraction in 100 ml of water. Analyze an aliquot of the redissolved sample for chlorides by IC using techniques similar to those described in Method 5F for sulfates. Previous drying of the sample should have removed all HCl. Therefore, the remaining chlorides measured by IC can be assumed to be NH_4Cl , and this weight can be subtracted from the weight determined for CPM.

8.3 Air Purge to Remove SO_2 from Impinger Contents. As an alternative to the post-test N_2 purge described in section 5.2.1, the tester may opt to conduct the post-test purge with air at 20 liter/min. Note: The use of an air purge is not as effective as a N_2 purge.

8.4 Chloroform-ether Extraction. As an alternative to the methylene chloride extraction described in section 5.3.2.1, the tester may opt to conduct a chloroform-ether extraction. Note: The Chloroform-ether was not as effective as the MeCl_2 in removing the organics, but it was found to be an acceptable organic extractant. Chloroform and diethylether of ACS grade, with low blank values (0.001 percent), shall be used. Analysis of the chloroform and diethylether blanks shall be conducted according to Section 5.3.3 for MeCl_2 .

8.4.1 Add the contents of Container No. 4 to a 1000-ml separatory funnel. Then add 75 ml of chloroform to the funnel, mix well, and drain off the lower organic phase. Repeat two more times with 75 ml of chloroform. Then perform three extractions with 75 ml of diethylether. This extraction should yield approximately 450 ml of organic extraction. Each time, leave a small amount of the organic/ MeCl_2 phase in the separatory funnel ensuring that no water is collected in the organic phase.

8.4.2 Add the contents of Container No. 5 to the organic extraction. Place approximately 300 ml of the organic extract in a tared 350-ml weighing tin while storing the remaining organic extract in a sample container. As the organic extract evaporates, add the remaining extract to the weighing tin.

8.4.3 Determine the weight of the organic phase as described in Section 5.3.2.2.

8.5 Improving Collection Efficiency. If low impinger collection efficiency is suspected, the following procedure may be used.

8.5.1 Place an out-of-stock filter as described in Method 8 between the second and third impingers.

8.5.2 Recover and analyze the filter according to Method 17, Section 4.2. Include the filter holder as part of the connecting glassware and handle as described in sections 5.2.2.2 and 5.2.2.3.

8.5.3 Calculate the Concentration of CPM as follows:

$$C_{\text{cpm}} = \frac{m_o + m_i + m_f - m_b}{VM_{\text{std}}} \quad \text{Eq. 202-5}$$

where:

m_f = amount of CPM collected on out-of-stock filter, mg.

8.6 Wet Source Testing. When testing at a wet source, use a heated out-of-stack filter as described in Method 5.

9. Bibliography

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2. DeWees, W.D. and K.C. Steinsberger. "Method Development and Evaluation of Draft Protocol for Measurement of Condensable Particulate Emissions." Draft Report. November 17, 1989.
3. Texas Air Control Board, Laboratory Division. "Determination of Particulate in Stack Gases Containing Sulfuric Acid and/or Sulfur Dioxide." *Laboratory Methods for Determination of Air Pollutants*. Modified December 3, 1976.
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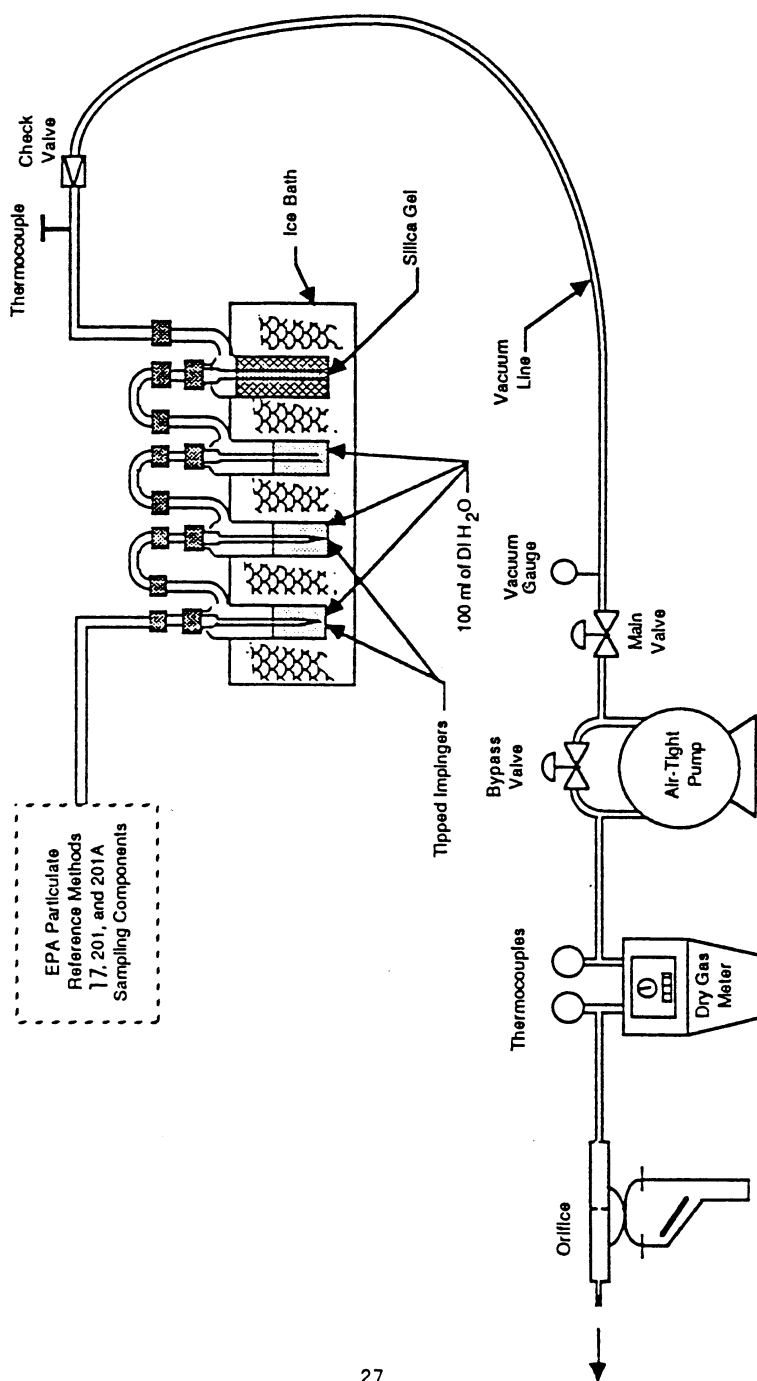


Figure 202-1. Schematic of condensible particulate sampling train.

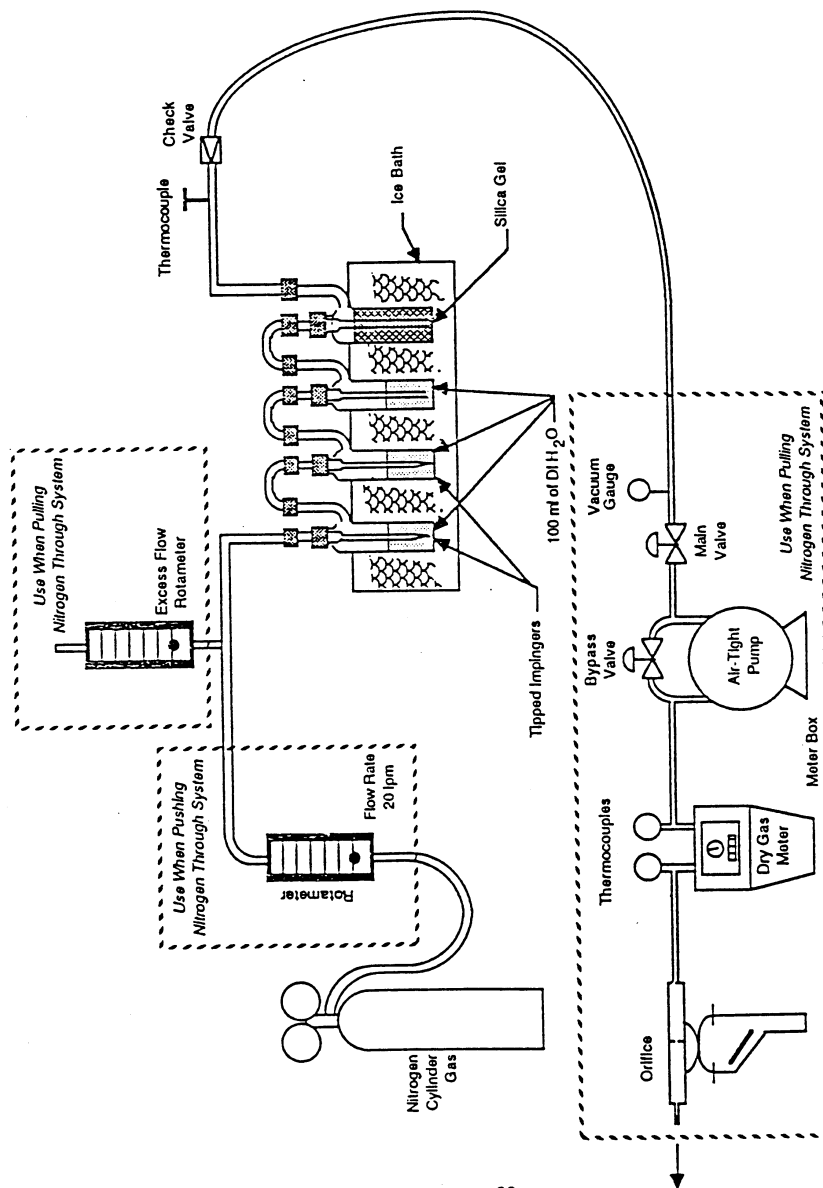


Figure 202-2. Schematic of post-test nitrogen purge system.

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Moisture Determination	Sample Preparation (Container No. 4)
Volume or weight of liquid in impingers: _____ ml or g	Amount of liquid lost during transport: _____ ml
Weight of moisture in silica gel: _____ g	Final volume: _____ ml
	pH of sample prior to analysis: _____

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Addition of NH₄ OH required: _____
Sample extracted 2X with 75 ml MeCl₂?: _____

For Titration of Sulfate

Normality of NH₂ OH: _____ N
Volume of sample titrated: _____ ml
Volume of titrant: _____ ml

Sample Analysis

Container number	Weight of condensable particulate, mg		
	Final weight	Tare weight	Weight gain
4 (Inorganic)
4 & 5 (Organic)

Total: _____
Less Blank: _____
Weight of Consensible Particulate:
Figure 202-3. Analytical data sheet.

METHOD 204—CRITERIA FOR AND VERIFICATION OF A PERMANENT OR TEMPORARY TOTAL ENCLOSURE

1. Scope and Application

This procedure is used to determine whether a permanent or temporary enclosure meets the criteria for a total enclosure. An existing building may be used as a temporary or permanent enclosure as long as it meets the appropriate criteria described in this method.

2. Summary of Method

An enclosure is evaluated against a set of criteria. If the criteria are met and if all the exhaust gases from the enclosure are ducted to a control device, then the volatile organic compounds (VOC) capture efficiency (CE) is assumed to be 100 percent, and CE need not be measured. However, if part of the exhaust gas stream is not ducted to a control device, CE must be determined.

3. Definitions

3.1 Natural Draft Opening (NDO). Any permanent opening in the enclosure that remains open during operation of the facility and is not connected to a duct in which a fan is installed.

3.2 Permanent Total Enclosure (PE). A permanently installed enclosure that completely surrounds a source of emissions such that all VOC emissions are captured and contained for discharge to a control device.

3.3 Temporary Total Enclosure (TTE). A temporarily installed enclosure that completely surrounds a source of emissions such that all VOC emissions that are not directed through the control device (i.e. uncaptured) are captured by the enclosure and contained for discharge through ducts that allow for

the accurate measurement of the uncaptured VOC emissions.

3.4 Building Enclosure (BE). An existing building that is used as a TTE.

4. Safety

An evaluation of the proposed building materials and the design for the enclosure is recommended to minimize any potential hazards.

5. Criteria for Temporary Total Enclosure

5.1 Any NDO shall be at least four equivalent opening diameters from each VOC emitting point unless otherwise specified by the Administrator.

5.2 Any exhaust point from the enclosure shall be at least four equivalent duct or hood diameters from each NDO.

5.3 The total area of all NDO's shall not exceed 5 percent of the surface area of the enclosure's four walls, floor, and ceiling.

5.4 The average facial velocity (FV) of air through all NDO's shall be at least 3,600 m/hr (200 fpm). The direction of air flow through all NDO's shall be into the enclosure.

5.5 All access doors and windows whose areas are not included in section 5.3 and are not included in the calculation in section 5.4 shall be closed during routine operation of the process.

6. Criteria for a Permanent Total Enclosure

6.1 Same as sections 5.1 and 5.3 through 5.5.

6.2 All VOC emissions must be captured and contained for discharge through a control device.

7. Quality Control

7.1 The success of this method lies in designing the TTE to simulate the conditions that exist without the TTE (i.e., the effect of the TTE on the normal flow patterns around the affected facility or the amount of uncaptured VOC emissions should be minimal). The TTE must enclose the application stations, coating reservoirs, and all areas from the application station to the oven. The oven does not have to be enclosed if it is under negative pressure. The NDO's of the temporary enclosure and an exhaust fan must be properly sized and placed.

7.2 Estimate the ventilation rate of the TTE that best simulates the conditions that exist without the TTE (i.e., the effect of the TTE on the normal flow patterns around the affected facility or the amount of uncaptured VOC emissions should be minimal). Figure 204-1 or the following equation may be used as an aid.

$$CE = \frac{Q_G C_G}{Q_G C_G + Q_F C_F} \quad \text{Eq. 204-1}$$

Measure the concentration (C_G) and flow rate (Q_G) of the captured gas stream, specify a safe concentration (C_F) for the uncaptured gas stream, estimate the CE, and then use the plot in Figure 204-1 or Equation 204-1 to determine the volumetric flow rate of the uncaptured gas stream (Q_F). An exhaust fan that has a variable flow control is desirable.

7.3 Monitor the VOC concentration of the captured gas stream in the duct before the capture device without the TTE. To minimize the effect of temporal variation on the captured emissions, the baseline measurement should be made over as long a time period as practical. However, the process conditions must be the same for the measurement in section 7.5 as they are for this baseline measurement. This may require short measuring times for this quality control check before and after the construction of the TTE.

7.4 After the TTE is constructed, monitor the VOC concentration inside the TTE. This concentration should not continue to increase, and must not exceed the safe level according to Occupational Safety and Health Administration requirements for permissible exposure limits. An increase in VOC concentration indicates poor TTE design.

7.5 Monitor the VOC concentration of the captured gas stream in the duct before the capture device with the TTE. To limit the effect of the TTE on the process, the VOC concentration with and without the TTE must be within 10 percent. If the measurements do not agree, adjust the ventilation rate from the TTE until they agree within 10 percent.

8. Procedure

8.1 Determine the equivalent diameters of the NDO's and determine the distances from each VOC emitting point to all NDO's. Determine the equivalent diameter of each exhaust duct or hood and its distance to all NDO's. Calculate the distances in terms of equivalent diameters. The number of equivalent diameters shall be at least four.

8.2 Measure the total surface area (A_T) of the enclosure and the total area (A_N) of all NDO's in the enclosure. Calculate the NDO to enclosure area ratio (NEAR) as follows:

$$\text{NEAR} = \frac{A_N}{A_T} \quad \text{Eq. 204-2}$$

The NEAR must be ≤ 10.05 .

8.3 Measure the volumetric flow rate, corrected to standard conditions, of each gas stream exiting the enclosure through an exhaust duct or hood using EPA Method 2. In some cases (e.g., when the building is the enclosure), it may be necessary to measure the volumetric flow rate, corrected to standard conditions, of each gas stream entering the enclosure through a forced makeup air duct using Method 2. Calculate FV using the following equation:

$$\text{FV} = \frac{Q_O - Q_I}{A_N} \quad \text{Eq. 204-3}$$

where:

Q_O = the sum of the volumetric flow from all gas streams exiting the enclosure through an exhaust duct or hood.

Q_I = the sum of the volumetric flow from all gas streams into the enclosure through a forced makeup air duct; zero, if there is no forced makeup air into the enclosure.

A_N = total area of all NDO's in enclosure.

The FV shall be at least 3,600 m/hr (200 fpm). Alternatively, measure the pressure differential across the enclosure. A pressure drop of 0.013 mm Hg (0.007 in. H_2O) corresponds to an FV of 3,600 m/hr (200 fpm).

8.4 Verify that the direction of air flow through all NDO's is inward. If FV is less than 9,000 m/hr (500 fpm), the continuous inward flow of air shall be verified using streamers, smoke tubes, or tracer gases. Monitor the direction of air flow for at least 1 hour, with checks made no more than 10 minutes apart. If FV is greater than 9,000 m/hr (500 fpm), the direction of air flow through the NDOs shall be presumed to be inward at all times without verification.

9. Diagrams

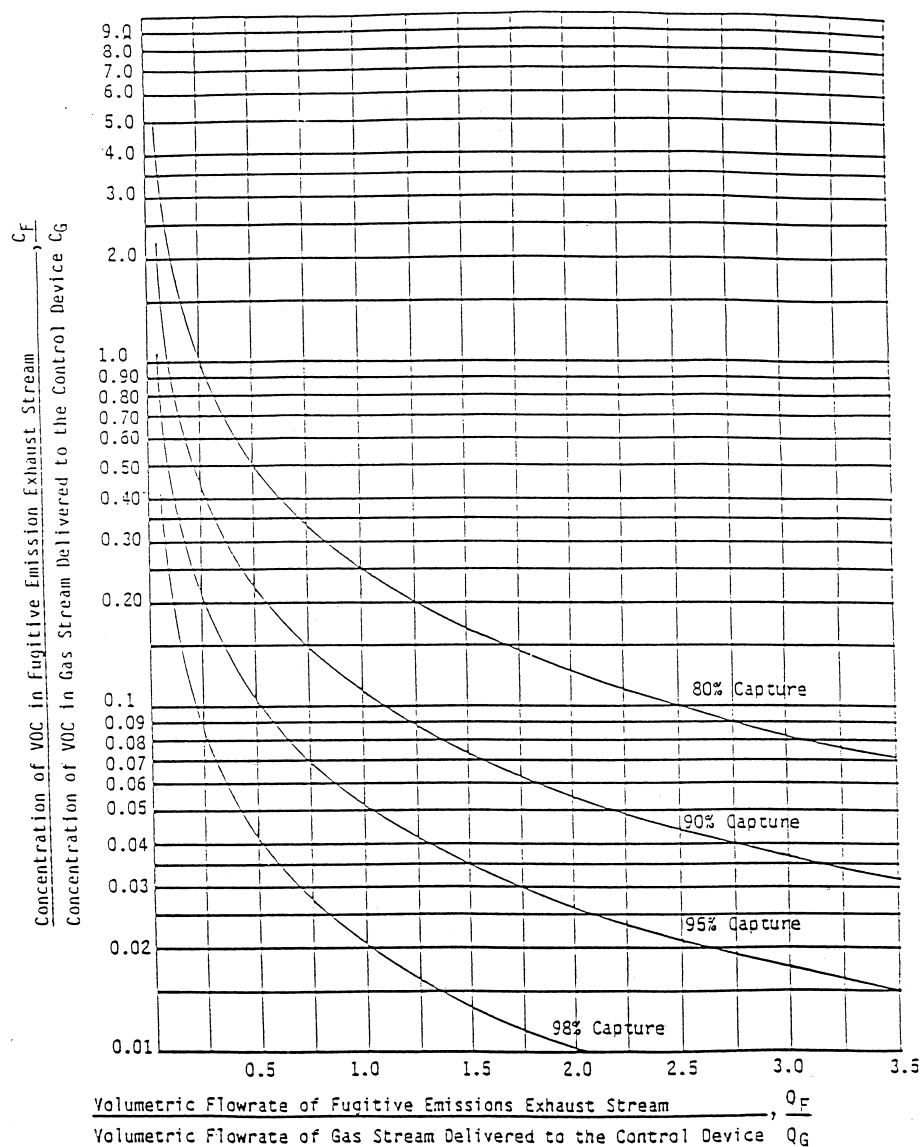


Figure 204-1. The crumpler chart.

METHOD 204A—VOLATILE ORGANIC COMPOUNDS CONTENT IN LIQUID INPUT STREAM

1. Scope and Application

1.1 Applicability. This procedure is applicable for determining the input of volatile organic compounds (VOC). It is intended to be used in the development of liquid/gas pro-

cedures for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of VOC introduced to the process (L) is the sum of the products of the weight (W) of each VOC containing liquid (ink, paint, solvent, etc.) used and its VOC content (V).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

The amount of VOC containing liquid introduced to the process is determined as the weight difference of the feed material before and after each sampling run. The VOC content of the liquid input material is determined by volatilizing a small aliquot of the material and analyzing the volatile material using a flame ionization analyzer (FIA). A sample of each VOC containing liquid is analyzed with an FIA to determine V.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Liquid Weight.

4.1.1 Balances/Digital Scales. To weigh drums of VOC containing liquids to within 0.2 lb or 1.0 percent of the total weight of VOC liquid used.

4.1.2 Volume Measurement Apparatus (Alternative). Volume meters, flow meters, density measurement equipment, etc., as needed to achieve the same accuracy as direct weight measurements.

4.2 VOC Content (FIA Technique). The liquid sample analysis system is shown in Figures 204A-1 and 204A-2. The following equipment is required:

4.2.1 Sample Collection Can. An appropriately-sized metal can to be used to collect VOC containing materials. The can must be constructed in such a way that it can be grounded to the coating container.

4.2.2 Needle Valves. To control gas flow.

4.2.3 Regulators. For carrier gas and calibration gas cylinders.

4.2.4 Tubing. Teflon or stainless steel tubing with diameters and lengths determined by connection requirements of equipment. The tubing between the sample oven outlet and the FIA shall be heated to maintain a temperature of $120 \pm 5^\circ\text{C}$.

4.2.5 Atmospheric Vent. A tee and 0- to 0.5-liter/min rotameter placed in the sampling line between the carrier gas cylinder and the VOC sample vessel to release the excess carrier gas. A toggle valve placed be-

tween the tee and the rotameter facilitates leak tests of the analysis system.

4.2.6 Thermometer. Capable of measuring the temperature of the hot water bath to within 1°C .

4.2.7 Sample Oven. Heated enclosure, containing calibration gas coil heaters, critical orifice, aspirator, and other liquid sample analysis components, capable of maintaining a temperature of $120 \pm 5^\circ\text{C}$.

4.2.8 Gas Coil Heaters. Sufficient lengths of stainless steel or Teflon tubing to allow zero and calibration gases to be heated to the sample oven temperature before entering the critical orifice or aspirator.

4.2.9 Water Bath. Capable of heating and maintaining a sample vessel temperature of $100 \pm 5^\circ\text{C}$.

4.2.10 Analytical Balance. To measure ± 0.001 g.

4.2.11 Disposable Syringes. 2-cc or 5-cc.

4.2.12 Sample Vessel. Glass, 40-ml septum vial. A separate vessel is needed for each sample.

4.2.13 Rubber Stopper. Two-hole stopper to accommodate 3.2-mm ($\frac{1}{8}$ -in.) Teflon tubing, appropriately sized to fit the opening of the sample vessel. The rubber stopper should be wrapped in Teflon tape to provide a tighter seal and to prevent any reaction of the sample with the rubber stopper. Alternatively, any leak-free closure fabricated of nonreactive materials and accommodating the necessary tubing fittings may be used.

4.2.14 Critical Orifices. Calibrated critical orifices capable of providing constant flow rates from 50 to 250 ml/min at known pressure drops. Sapphire orifice assemblies (available from O'Keefe Controls Company) and glass capillary tubing have been found to be adequate for this application.

4.2.15 Vacuum Gauge. Zero to 760-mm (0- to 30-in.) Hg U-Tube manometer or vacuum gauge.

4.2.16 Pressure Gauge. Bourdon gauge capable of measuring the maximum air pressure at the aspirator inlet (e.g., 100 psig).

4.2.17 Aspirator. A device capable of generating sufficient vacuum at the sample vessel to create critical flow through the calibrated orifice when sufficient air pressure is present at the aspirator inlet. The aspirator must also provide sufficient sample pressure to operate the FIA. The sample is also mixed with the dilution gas within the aspirator.

4.2.18 Soap Bubble Meter. Of an appropriate size to calibrate the critical orifices in the system.

4.2.19 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated that they would provide more accurate measurements. The FIA instrument should be the same instrument used in the gaseous analyses adjusted with the same

fuel, combustion air, and sample back-pressure (flow rate) settings. The system shall be capable of meeting or exceeding the following specifications:

4.2.19.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.2.19.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.2.19.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.2.20 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2.21 Chart Recorder (Optional). A chart recorder or similar device is recommended to provide a continuous analog display of the measurement results during the liquid sample analysis.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's

satisfaction that equally accurate measurements would be achieved.

5.1.4 System Calibration Gas. Gas mixture standard containing propane in air, approximating the undiluted VOC concentration expected for the liquid samples.

6. Sample Collection, Preservation and Storage

6.1 Samples must be collected in a manner that prevents or minimizes loss of volatile components and that does not contaminate the coating reservoir.

6.2 Collect a 100-ml or larger sample of the VOC containing liquid mixture at each application location at the beginning and end of each test run. A separate sample should be taken of each VOC containing liquid added to the application mixture during the test run. If a fresh drum is needed during the sampling run, then obtain a sample from the fresh drum.

6.3 When collecting the sample, ground the sample container to the coating drum. Fill the sample container as close to the rim as possible to minimize the amount of headspace.

6.4 After the sample is collected, seal the container so the sample cannot leak out or evaporate.

6.5 Label the container to clearly identify the contents.

7. Quality Control

7.1 Required instrument quality control parameters are found in the following sections:

7.1.1 The FIA system must be calibrated as specified in section 8.1.

7.1.2 The system drift check must be performed as specified in section 8.2.

7.2 Audits.

7.2.1 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

7.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and

Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

7.2.3 **Audit Results.** Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

8. Calibration and Standardization

8.1 **FIA Calibration and Linearity Check.** Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero- and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

8.2 **Systems Drift Checks.** After each sample, repeat the system calibration checks in section 9.2.7 before any adjustments to the FIA or measurement system are made. If the zero or calibration drift exceeds ± 3 percent of the span value, discard the result and repeat the analysis.

Alternatively, recalibrate the FIA as in section 8.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run.

8.3 Critical Orifice Calibration.

8.3.1 Each critical orifice must be calibrated at the specific operating conditions under which it will be used. Therefore, as-

semble all components of the liquid sample analysis system as shown in Figure 204A-3. A stopwatch is also required.

8.3.2 Turn on the sample oven, sample line, and water bath heaters, and allow the system to reach the proper operating temperature. Adjust the aspirator to a vacuum of 380 mm (15 in.) Hg vacuum. Measure the time required for one soap bubble to move a known distance and record barometric pressure.

8.3.3 Repeat the calibration procedure at a vacuum of 406 mm (16 in.) Hg and at 25-mm (1-in.) Hg intervals until three consecutive determinations provide the same flow rate. Calculate the critical flow rate for the orifice in ml/min at standard conditions. Record the vacuum necessary to achieve critical flow.

9. Procedure

9.1 Determination of Liquid Input Weight.

9.1.1 **Weight Difference.** Determine the amount of material introduced to the process as the weight difference of the feed material before and after each sampling run. In determining the total VOC containing liquid usage, account for:

- (a) The initial (beginning) VOC containing liquid mixture.
- (b) Any solvent added during the test run.
- (c) Any coating added during the test run.
- (d) Any residual VOC containing liquid mixture remaining at the end of the sample run.

9.1.1.1 Identify all points where VOC containing liquids are introduced to the process. To obtain an accurate measurement of VOC containing liquids, start with an empty fountain (if applicable). After completing the run, drain the liquid in the fountain back into the liquid drum (if possible) and weigh the drum again. Weigh the VOC containing liquids to ± 0.5 percent of the total weight (full) or ± 1.0 percent of the total weight of VOC containing liquid used during the sample run, whichever is less. If the residual liquid cannot be returned to the drum, drain the fountain into a preweighed empty drum to determine the final weight of the liquid.

9.1.1.2 If it is not possible to measure a single representative mixture, then weigh the various components separately (e.g., if solvent is added during the sampling run, weigh the solvent before it is added to the mixture). If a fresh drum of VOC containing liquid is needed during the run, then weigh both the empty drum and fresh drum.

9.1.2 **Volume Measurement (Alternative).** If direct weight measurements are not feasible, the tester may use volume meters or flow rate meters and density measurements to determine the weight of liquids used if it can be demonstrated that the technique produces results equivalent to the direct weight measurements. If a single representative

mixture cannot be measured, measure the components separately.

9.2 Determination of VOC Content in Input Liquids

9.2.1 Assemble the liquid VOC content analysis system as shown in Figure 204A-1.

9.2.2 Permanently identify all of the critical orifices that may be used. Calibrate each critical orifice under the expected operating conditions (i.e., sample vacuum and temperature) against a volume meter as described in section 8.3.

9.2.3 Label and tare the sample vessels (including the stoppers and caps) and the syringes.

9.2.4 Install an empty sample vessel and perform a leak test of the system. Close the carrier gas valve and atmospheric vent and evacuate the sample vessel to 250 mm (10 in.) Hg absolute or less using the aspirator. Close the toggle valve at the inlet to the aspirator and observe the vacuum for at least 1 minute. If there is any change in the sample pressure, release the vacuum, adjust or repair the apparatus as necessary, and repeat the leak test.

9.2.5 Perform the analyzer calibration and linearity checks according to the procedure in section 5.1. Record the responses to each of the calibration gases and the back-pressure setting of the FIA.

9.2.6 Establish the appropriate dilution ratio by adjusting the aspirator air supply or substituting critical orifices. Operate the aspirator at a vacuum of at least 25 mm (1 in.) Hg greater than the vacuum necessary to achieve critical flow. Select the dilution ratio so that the maximum response of the FIA to the sample does not exceed the high-range calibration gas.

9.2.7 Perform system calibration checks at two levels by introducing compressed gases at the inlet to the sample vessel while the aspirator and dilution devices are operating. Perform these checks using the carrier gas (zero concentration) and the system calibration gas. If the response to the carrier gas exceeds ± 0.5 percent of span, clean or repair the apparatus and repeat the check. Adjust the dilution ratio as necessary to achieve the correct response to the upscale check, but do not adjust the analyzer calibration. Record the identification of the orifice, aspirator air supply pressure, FIA back-pressure, and the responses of the FIA to the carrier and system calibration gases.

9.2.8 After completing the above checks, inject the system calibration gas for approximately 10 minutes. Time the exact duration of the gas injection using a stopwatch. Determine the area under the FIA response curve and calculate the system response factor based on the sample gas flow rate, gas concentration, and the duration of the injection as compared to the integrated response using Equations 204A-2 and 204A-3.

9.2.9 Verify that the sample oven and sample line temperatures are 120 ± 5 °C and that the water bath temperature is 100 ± 5 °C.

9.2.10 Fill a tared syringe with approximately 1 g of the VOC containing liquid and weigh it. Transfer the liquid to a tared sample vessel. Plug the sample vessel to minimize sample loss. Weigh the sample vessel containing the liquid to determine the amount of sample actually received. Also, as a quality control check, weigh the empty syringe to determine the amount of material delivered. The two coating sample weights should agree within 0.02 g. If not, repeat the procedure until an acceptable sample is obtained.

9.2.11 Connect the vessel to the analysis system. Adjust the aspirator supply pressure to the correct value. Open the valve on the carrier gas supply to the sample vessel and adjust it to provide a slight excess flow to the atmospheric vent. As soon as the initial response of the FIA begins to decrease, immerse the sample vessel in the water bath. (Applying heat to the sample vessel too soon may cause the FIA response to exceed the calibrated range of the instrument and, thus, invalidate the analysis.)

9.2.12 Continuously measure and record the response of the FIA until all of the volatile material has been evaporated from the sample and the instrument response has returned to the baseline (i.e., response less than 0.5 percent of the span value). Observe the aspirator supply pressure, FIA back-pressure, atmospheric vent, and other system operating parameters during the run; repeat the analysis procedure if any of these parameters deviate from the values established during the system calibration checks in section 9.2.7. After each sample, perform the drift check described in section 8.2. If the drift check results are acceptable, calculate the VOC content of the sample using the equations in section 11.2. Alternatively, recalibrate the FIA as in section 8.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Integrate the area under the FIA response curve, or determine the average concentration response and the duration of sample analysis.

10. Data Analysis and Calculations

10.1 Nomenclature.

A_L =area under the response curve of the liquid sample, area count.

A_S =area under the response curve of the calibration gas, area count.

C_S =actual concentration of system calibration gas, ppm propane.

$K=1.830 \times 10^{-9}$ g/(ml-ppm).

L =total VOC content of liquid input, kg.

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M_L =mass of liquid sample delivered to the sample vessel, g.
 q = flow rate through critical orifice, ml/min.
 RF =liquid analysis system response factor, g/area count.
 θ_S =total gas injection time for system calibration gas during integrator calibration, min.
 V_{Fj} =final VOC fraction of VOC containing liquid j.
 V_{ij} =initial VOC fraction of VOC containing liquid j.

V_{Aj} =VOC fraction of VOC containing liquid j added during the run.
 V =VOC fraction of liquid sample.
 W_{Fj} =weight of VOC containing liquid j remaining at end of the run, kg.
 W_{ij} =weight of VOC containing liquid j at beginning of the run, kg.
 W_{Aj} =weight of VOC containing liquid j added during the run, kg.
10.2 Calculations
10.2.1 Total VOC Content of the Input VOC Containing Liquid.

$$L = \sum_{j=1}^n V_{ij} W_{ij} - \sum_{j=1}^n V_{Fj} W_{Fj} + \sum_{j=1}^n V_{Aj} W_{Aj} \quad \text{Eq. 204A-1}$$

10.2.2 Liquid Sample Analysis System Response Factor for Systems Using Integrators, Grams/Area Count.

$$RF = \frac{C_S q \theta_S K}{A_S} \quad \text{Eq. 204A-2}$$

10.2.3 VOC Content of the Liquid Sample.

$$V = \frac{A_L RF}{M_L} \quad \text{Eq. 204A-3}$$

11. Method Performance

The measurement uncertainties are estimated for each VOC containing liquid as follows: $W = \pm 2.0$ percent and $V = \pm 4.0$ percent. Based on these numbers, the probable uncertainty for L is estimated at about ± 4.5 percent for each VOC containing liquid.

12. Diagrams

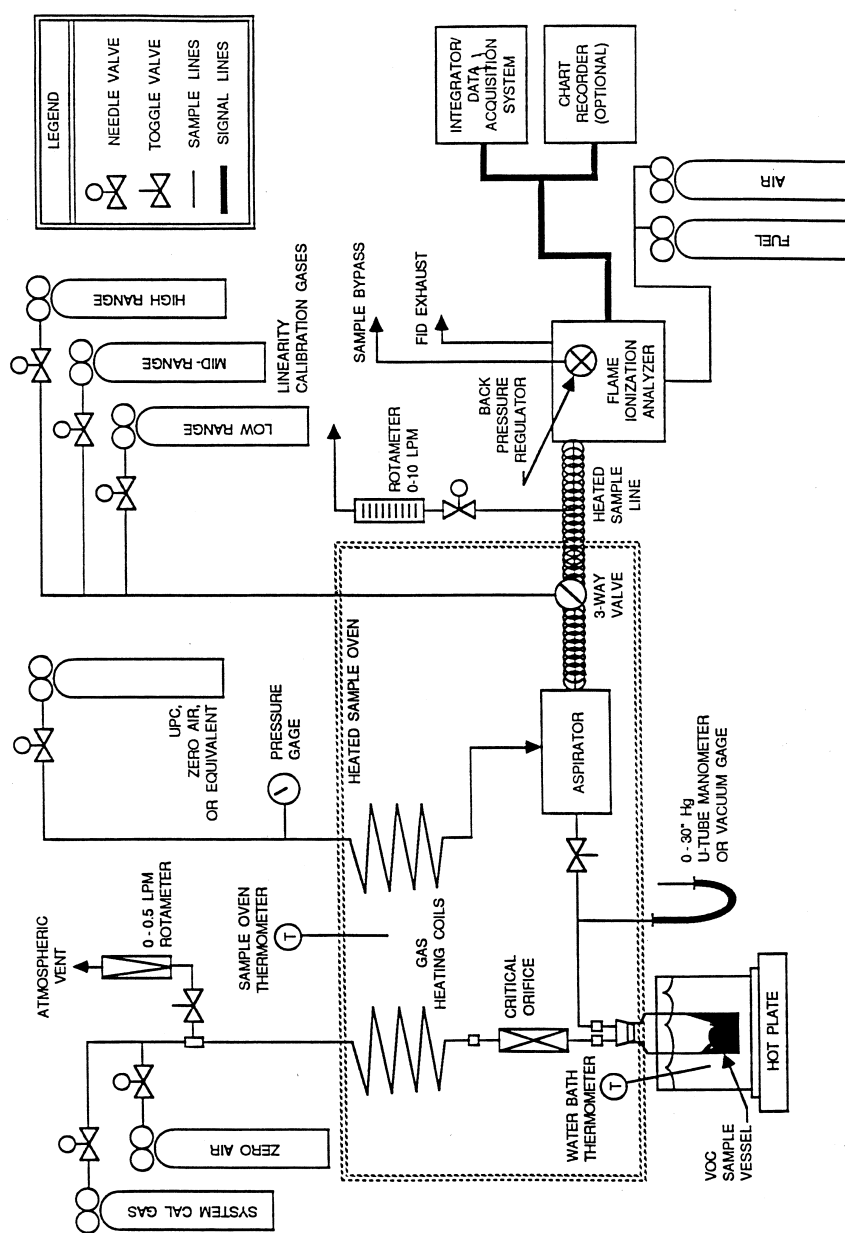


Figure 204A-1. Liquid analysis sample system.

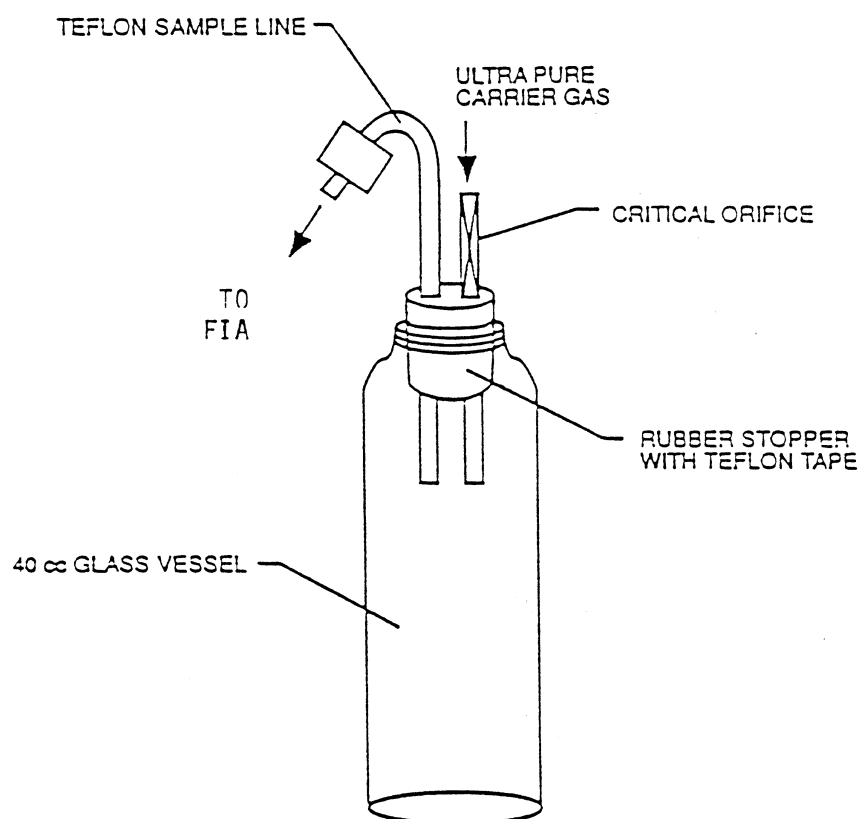


Figure 204A-2. VOC sampling vessel.

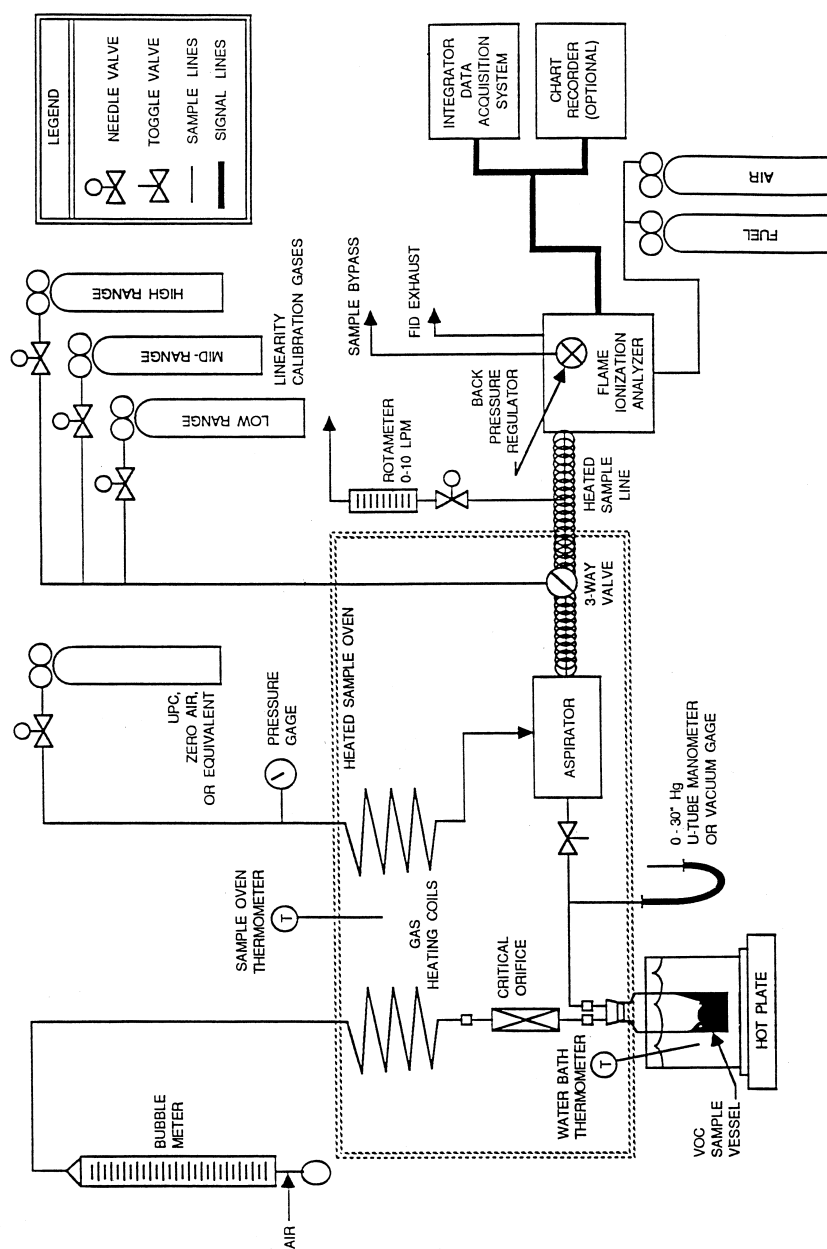


Figure 204A-3. Critical orifice calibration apparatus.

METHOD 204B—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN CAPTURED STREAM*1. Scope and Application*

1.1 Applicability. This procedure is applicable for determining the volatile organic compounds (VOC) content of captured gas streams. It is intended to be used in the development of a gas/gas protocol for determining VOC capture efficiency (CE) for surface coating and printing operations. The procedure may not be acceptable in certain site-specific situations [e.g., when: (1) direct-fired heaters or other circumstances affect the quantity of VOC at the control device inlet; and (2) particulate organic aerosols are formed in the process and are present in the captured emissions].

1.2 Principle. The amount of VOC captured (G) is calculated as the sum of the products of the VOC content (C_{Gj}), the flow rate (Q_{Gj}), and the sample time (Θ_c) from each captured emissions point.

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the source through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204B-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the

analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow rate control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.6.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.6.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.6.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.6.4 Response Time. Less than 30 seconds.

4.1.7 Integrator/Data Acquisition System. An analog or digital device, or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Captured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of

the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Tri-

angle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value

shall be reported as the results for the test run. Conduct the system drift checks at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before and after each test run.

8. Procedure

8.1. Determination of Volumetric Flow Rate of Captured Emissions.

8.1.1 Locate all points where emissions are captured from the affected facility. Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.1.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Captured Emissions.

8.2.1 Analysis Duration. Measure the VOC responses at each captured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple captured emission locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204B-1. Calibrate the FIA according to the procedure in section 7.1.

8.2.2.2 Conduct a system check according to the procedure in section 7.3.

8.2.2.3 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.4 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.5 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.6 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.7 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information as appropriate. If multiple captured emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 minutes) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the measurements at each sampling location until two times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

NOTE: Not applicable when the building is used as the temporary total enclosure (TTE).

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise specified by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204B-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3.

NOTE: This sample train shall be separate from the sample train used to measure the captured emissions.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.4 through 8.2.2.7.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the captured emissions, it must also be used to determine the VOC concentration of the uncaptured emissions.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i, ft².

A_N =total area of all NDO's in the enclosure, ft².

C_{Bi} =corrected average VOC concentration of background emissions at point i, ppm propane.

C_B =average background concentration, ppm propane.

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C_{Gj} =corrected average VOC concentration of captured emissions at point j, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration measured at point i, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

G =total VOC content of captured emissions, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n =number of measurement points.

Q_{Gj} =average effluent volumetric flow rate corrected to standard conditions at captured emissions point j, m³/min.

θ_C =total duration of captured emissions.

9.2 Calculations.

9.2.1 Total VOC Captured Emissions.

$$G = \sum_{j=1}^n (C_{Gj} - C_B) Q_{Gj} \theta_C K_1 \quad \text{Eq. 204B-1}$$

9.2.2 VOC Concentration of the Captured Emissions at Point j.

$$C_{Gj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204B-2}$$

9.2.3 Background VOC Concentration at Point i.

$$C_{Bi} = (C_i - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204B-3}$$

9.2.4 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204B-4}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, then use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each captured or uncaptured emissions point as follows: $Q_{Gj}=\pm 5.5$ percent and $C_{Gj}=\pm 5.0$ percent. Based on these numbers, the probable uncertainty for G is estimated at about ± 7.4 percent.

11. Diagrams

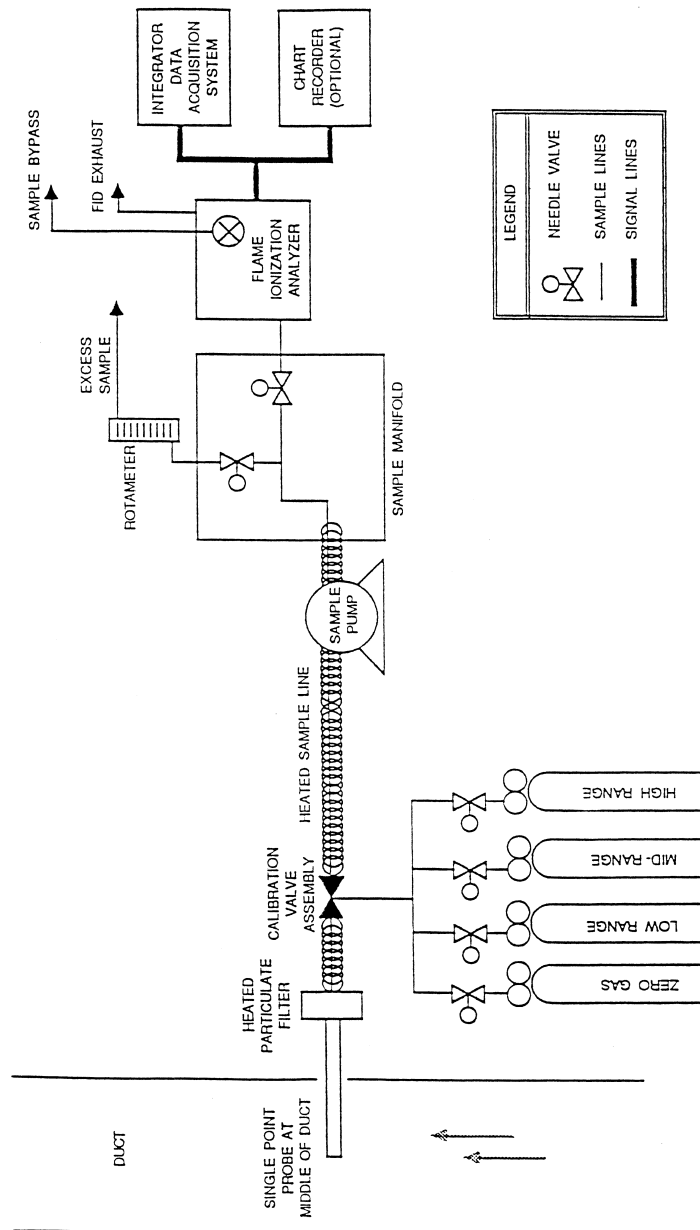


Figure 204b-1. Gas VOC concentration measurement system.

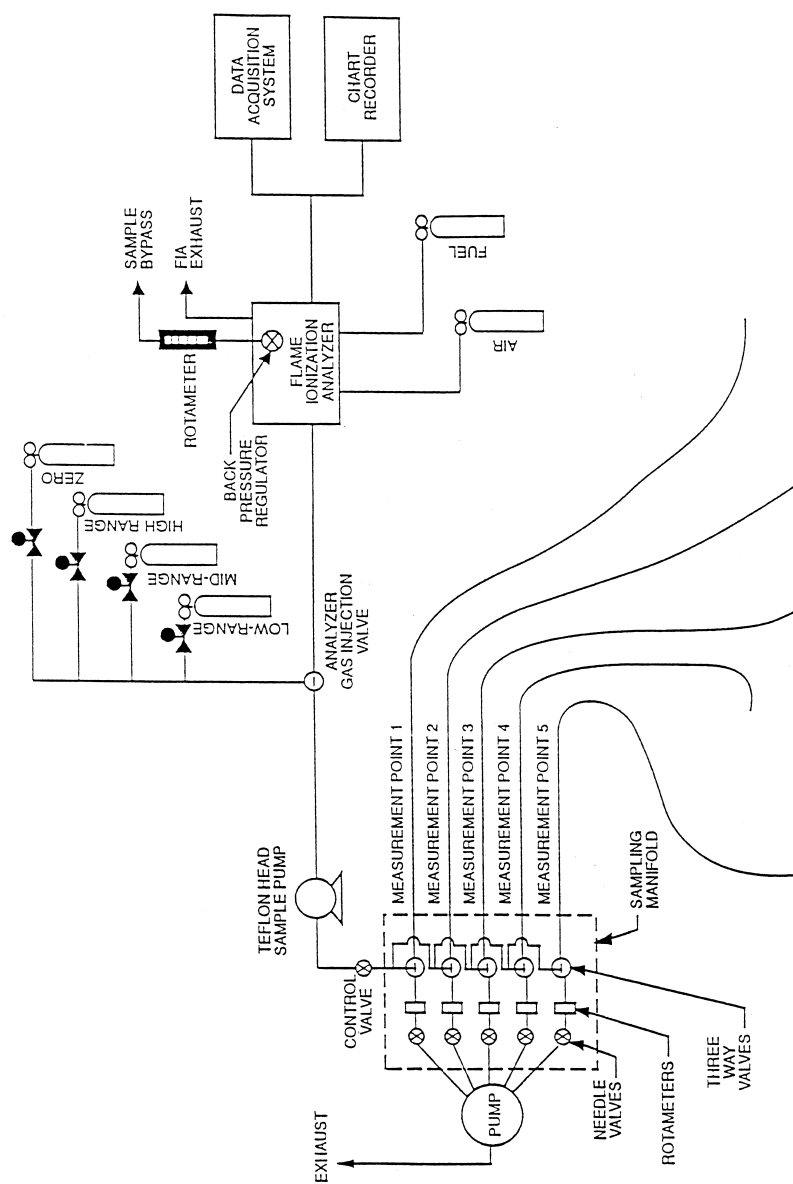


Figure 204B-2. Background measurement system.

METHOD 204C—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN CAPTURED STREAM (DILUTION
TECHNIQUE)*1. Scope and Application*

1.1 Applicability. This procedure is applicable for determining the volatile organic compounds (VOC) content of captured gas streams. It is intended to be used in the development of a gas/gas protocol in which uncaptured emissions are also measured for determining VOC capture efficiency (CE) for surface coating and printing operations. A dilution system is used to reduce the VOC concentration of the captured emissions to about the same concentration as the uncaptured emissions. The procedure may not be acceptable in certain site-specific situations [e.g., when: (1) direct-fired heaters or other circumstances affect the quantity of VOC at the control device inlet; and (2) particulate organic aerosols are formed in the process and are present in the captured emissions].

1.2 Principle. The amount of VOC captured (G) is calculated as the sum of the products of the VOC content (C_{Gi}), the flow rate (Q_{Gi}), and the sampling time (Θ_c) from each captured emissions point.

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the source using an in-stack dilution probe through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA). The sample train contains a sample gas manifold which allows multiple points to be sampled using a single FIA.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204C-1. The main components are as follows:

4.1.1 Dilution System. A Kipp in-stack dilution probe and controller or similar device may be used. The dilution rate may be

changed by substituting different critical orifices or adjustments of the aspirator supply pressure. The dilution system shall be heated to prevent VOC condensation. Note: An out-of-stack dilution device may be used.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Sample Gas Manifold. Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If captured or uncaptured emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location and a common sample gas manifold and FIA. The sample gas manifold and connecting lines to the FIA must be heated to prevent condensation.

NOTE: Depending on the number of sampling points and their location, it may not be possible to use only one FIA. However to reduce the effect of calibration error, the number of FIA's used during a test should be kept as small as possible.

4.1.7 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.7.2 Calibration Drift. Less than ± 3.0 percent of the span value.

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4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Captured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas and Dilution Air Supply. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent), or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20–30, 45–55, and 70–80 percent of the span value in air, respectively. Other calibration values and other span values may be

used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.1.4 Dilution Check Gas. Gas mixture standard containing propane in air, approximately half the span value after dilution.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The dilution factor must be determined as specified in section 7.3.

6.1.4 The system check must be conducted as specified in section 7.4.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system after the dilution system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the diluted captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly, and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Conduct the system drift check at the end of each run.

7.3 Determination of Dilution Factor. Inject the dilution check gas into the measurement system before the dilution system and record the response. Calculate the dilution factor using Equation 204C-3.

7.4 System Check. Inject the high-range calibration gas at the inlet to the sampling probe while the dilution air is turned off. Record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before and after each test run.

8. Procedure

8.1 Determination of Volumetric Flow Rate of Captured Emissions

8.1.1 Locate all points where emissions are captured from the affected facility.

Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.2.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Captured Emissions

8.2.1 Analysis Duration. Measure the VOC responses at each captured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple captured emissions locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204C-1. Calibrate the FIA according to the procedure in section 7.1.

8.2.2.2 Set the dilution ratio and determine the dilution factor according to the procedure in section 7.3.

8.2.2.3 Conduct a system check according to the procedure in section 7.4.

8.2.2.4 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.5 Inject zero gas at the calibration valve assembly. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.6 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.4. If the drift check following a run indicates unacceptable performance (see section 7.4), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.7 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.8 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information as appropriate. If multiple captured emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 min.) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the measurements at each sampling

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location until two times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

NOTE: Not applicable when the building is used as the temporary total enclosure (TTE).

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise approved by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204C-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.4.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.4 through 8.2.2.8.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the captured emissions, it must also be used to determine the VOC concentration of the uncaptured emissions.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i, ft².

A_N =total area of all NDO's in the enclosure, ft².

C_A = actual concentration of the dilution check gas, ppm propane.

C_{Bi} =corrected average VOC concentration of background emissions at point i, ppm propane.

C_B =average background concentration, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration measured at point i, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

C_M =measured concentration of the dilution check gas, ppm propane.

DF=dilution factor.

G=total VOC content of captured emissions, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n=number of measurement points.

Q_{Gj} =average effluent volumetric flow rate corrected to standard conditions at captured emissions point j, m³/min.

Θ_C =total duration of CE sampling run, min.

9.2 Calculations.

9.2.1 Total VOC Captured Emissions.

$$G = \sum_{j=1}^n (C_{Gj} - C_B) Q_{Gj} \Theta_C K_1 \quad \text{Eq. 204C-1}$$

9.2.2 VOC Concentration of the Captured Emissions at Point j.

$$C_{Gj} = DF (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204C-2}$$

9.2.3 Dilution Factor.

$$DF = \frac{C_A}{C_M} \quad \text{Eq. 204C-3}$$

9.2.4 Background VOC Concentration at Point i.

$$C_{Bi} = (C_i - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204C-4}$$

9.2.5 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204C-5}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, then use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each captured or uncaptured emissions point as follows: $Q_{Gj}=\pm 5.5$ percent and $C_{Gj}=\pm 5$ percent. Based on these numbers, the probable uncertainty for G is estimated at about ± 7.4 percent.

11. Diagrams

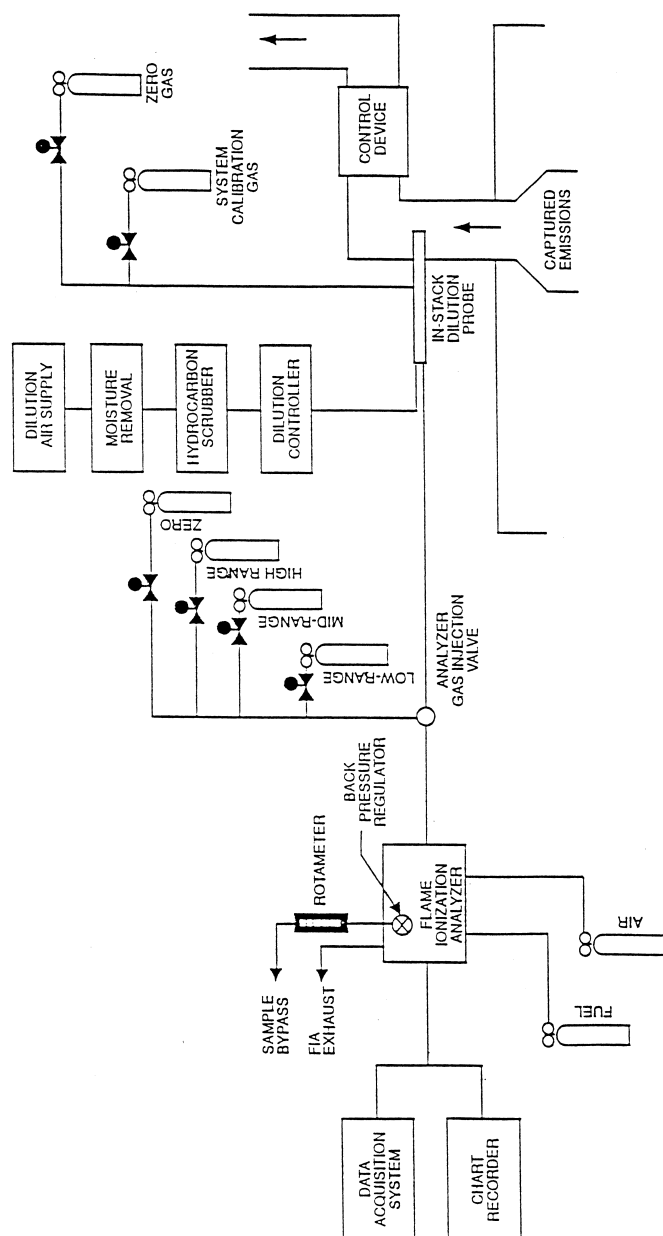


Figure 204C-1. Captured emissions measurement system.

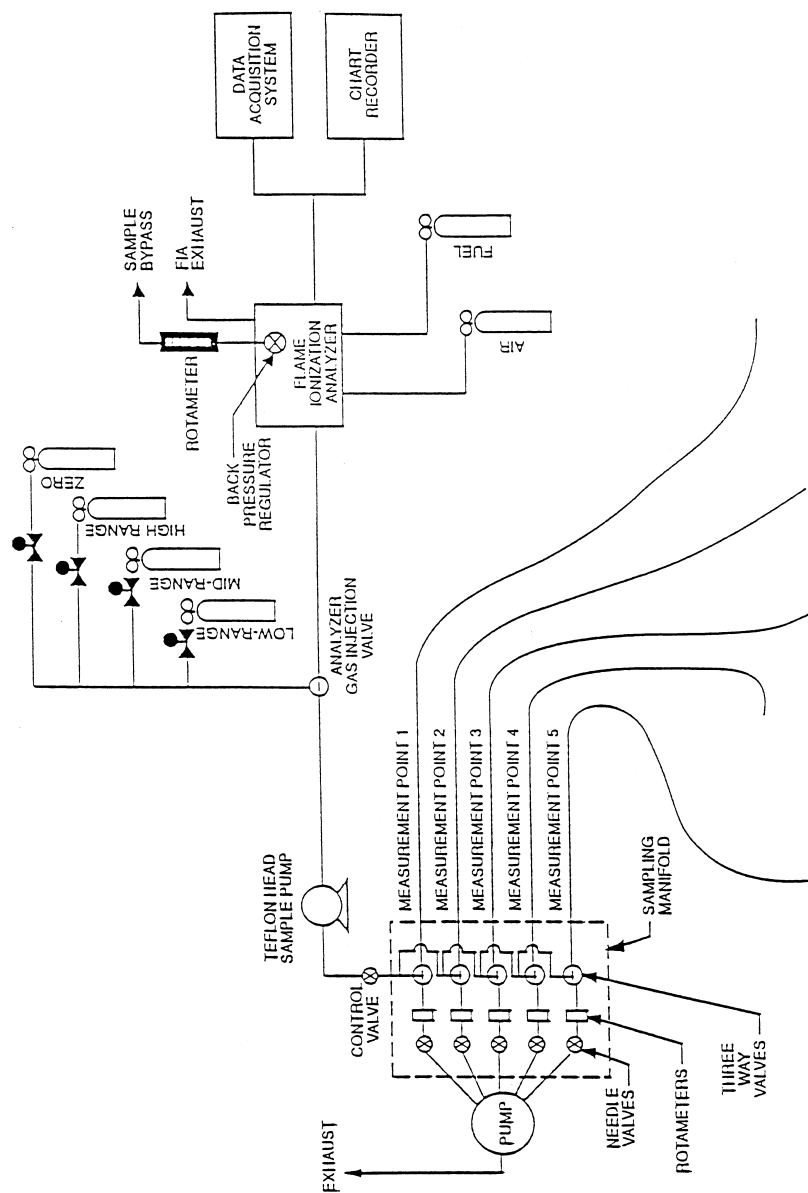


Figure 204C-2. Background measurement system.

METHOD 204D—VOLATILE ORGANIC COMPOUNDS EMISSIONS IN UNCAPPED STREAM FROM TEMPORARY TOTAL ENCLOSURE

1. Scope and Application

1.1 Applicability. This procedure is applicable for determining the uncaptured vola-

tile organic compounds (VOC) emissions from a temporary total enclosure (TTE). It is intended to be used as a segment in the development of liquid/gas or gas/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of uncaptured VOC emissions (F) from the TTE is calculated as the sum of the products of the VOC content (C_{Fi}), the flow rate (Q_{Fi}) from each uncaptured emissions point, and the sampling time (Θ_T).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the uncaptured exhaust duct of a TTE through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204D-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow control valve and rotameter must be heated to prevent condensation. A control valve may also

be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Sample Gas Manifold. Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location and a common sample gas manifold and FIA. The sample gas manifold and connecting lines to the FIA must be heated to prevent condensation.

4.1.7 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide more accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.7.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Uncaptured Emissions Volumetric Flow Rate.

4.2.1 Method 2 or 2A Apparatus. For determining volumetric flow rate.

4.2.2 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.3 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

4.3 Temporary Total Enclosure. The criteria for designing an acceptable TTE are specified in Method 204.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of

the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (as propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B) Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Tri-

angle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas concentration that most closely approximates that of the uncaptured gas emissions concentration to conduct the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the

lowest CE value shall be reported as the results for the test run. Conduct a system drift check at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before each test run.

8. Procedure

8.1 Determination of Volumetric Flow Rate of Uncaptured Emissions

8.1.1 Locate all points where uncaptured emissions are exhausted from the TTE. Using Method 1, determine the sampling points. Be sure to check each site for cyclonic or swirling flow.

8.1.2 Measure the velocity at each sampling site at least once every hour during each sampling run using Method 2 or 2A.

8.2 Determination of VOC Content of Uncaptured Emissions.

8.2.1 Analysis Duration. Measure the VOC responses at each uncaptured emission point during the entire test run or, if applicable, while the process is operating. If there are multiple emission locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.2.2 Gas VOC Concentration.

8.2.2.1 Assemble the sample train as shown in Figure 204D-1. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3, respectively.

8.2.2.2 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.2.2.3 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.2.2.4 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform system drift checks during the run not to exceed one drift check per hour.

8.2.2.5 Verify that the sample lines, filter, and pump temperatures are 120 ± 5 °C.

8.2.2.6 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times and any required process information, as appropriate. If multiple emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 min.) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the response measurements at each sampling location until 2 times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute and record the concentration measurements.

8.2.3 Background Concentration.

8.2.3.1 Locate all natural draft openings (NDO's) of the TTE. A sampling point shall be at the center of each NDO, unless otherwise approved by the Administrator. If there are more than six NDO's, choose six sampling points evenly spaced among the NDO's.

8.2.3.2 Assemble the sample train as shown in Figure 204D-2. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3.

8.2.3.3 Position the probe at the sampling location.

8.2.3.4 Determine the response time, conduct the system check, and sample according to the procedures described in sections 8.2.2.3 through 8.2.2.6.

8.2.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the uncaptured emissions in a gas/gas protocol, it must also be used to determine the VOC concentration of the captured emissions. If a tester wishes to conduct a liquid/gas protocol using a gas chromatograph, the tester must use Method 204F for the liquid stream. A gas chromatograph is not an acceptable alternative to the FIA in Method 204A.

9. Data Analysis and Calculations

9.1 Nomenclature.

A_i =area of NDO i, ft².

A_N =total area of all NDO's in the enclosure, ft².

C_{Bi} =corrected average VOC concentration of background emissions at point i, ppm propane.

C_B =average background concentration, ppm propane.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

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C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_{Fj} =corrected average VOC concentration of uncaptured emissions at point j, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_i =uncorrected average background VOC concentration at point i, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

F =total VOC content of uncaptured emissions, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n =number of measurement points.

Q_{Fj} =average effluent volumetric flow rate corrected to standard conditions at uncaptured emissions point j, m³/min.

Θ_F =total duration of uncaptured emissions sampling run, min.

9.2 Calculations.

9.2.1 Total Uncaptured VOC Emissions.

$$F = \sum_{j=1}^n (C_{Fj} - C_B) Q_{Fj} \Theta_F K_1 \quad \text{Eq. 204D-1}$$

9.2.2 VOC Concentration of the Uncaptured Emissions at Point j.

$$C_{Fj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204D-2}$$

9.2.3 Background VOC Concentration at Point i.

$$C_{Bi} = (C_i - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204D-3}$$

9.2.4 Average Background Concentration.

$$C_B = \frac{\sum_{i=1}^n C_{Bi} A_i}{A_N} \quad \text{Eq. 204D-4}$$

NOTE: If the concentration at each point is within 20 percent of the average concentration of all points, use the arithmetic average.

10. Method Performance

The measurement uncertainties are estimated for each uncaptured emission point as follows: $Q_{Fj}=\pm 5.5$ percent and $C_{Fj}=\pm 5.0$ percent. Based on these numbers, the probable uncertainty for F is estimated at about ± 7.4 percent.

11. Diagrams

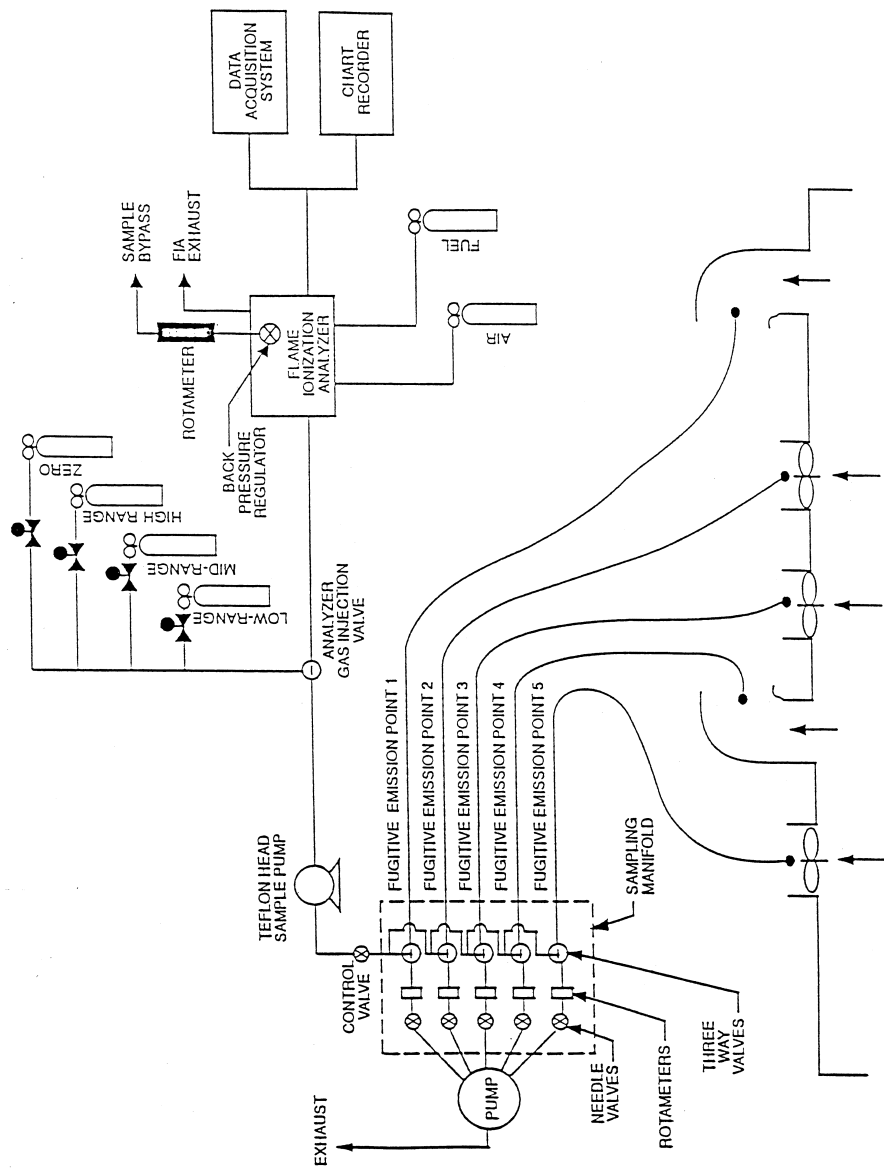


Figure 2040-1. Fugitive emissions measurement system.

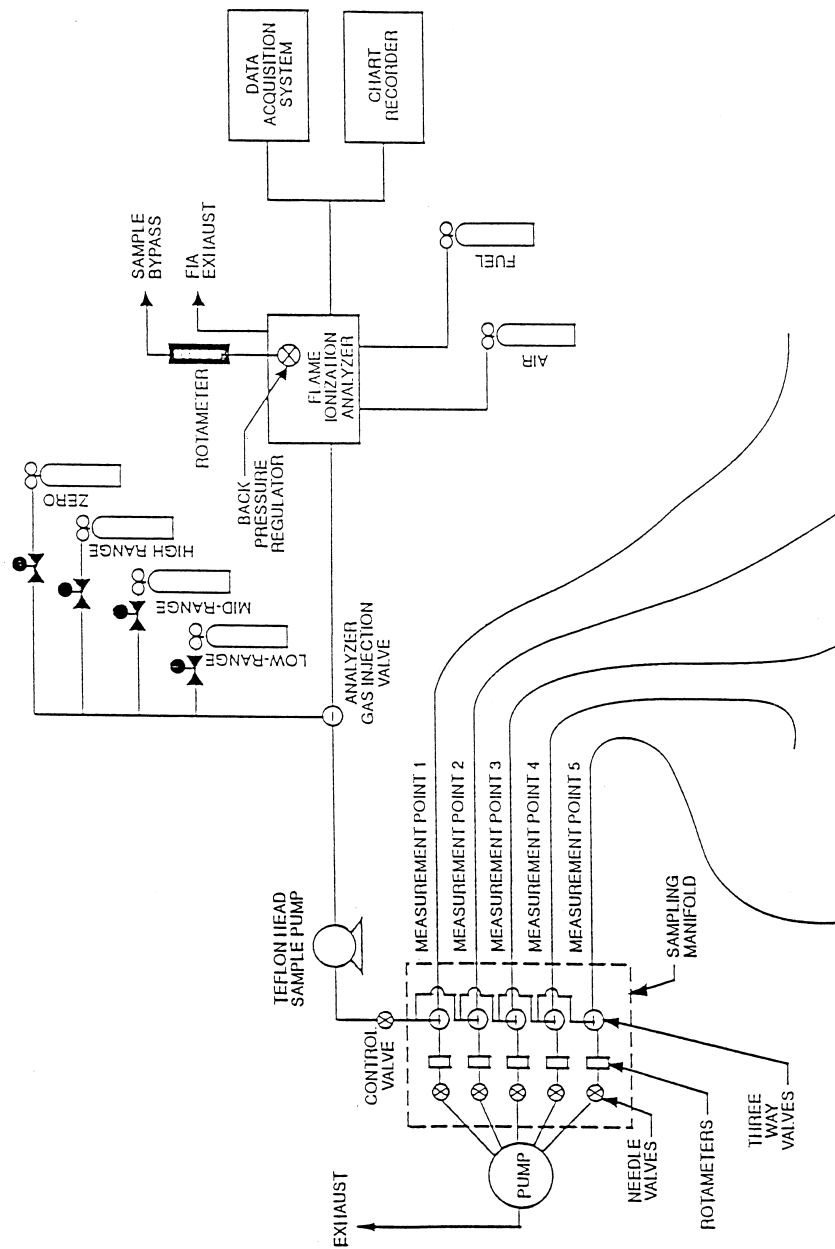


Figure 204D-2. Background measurement system.

METHOD 204E—VOLATILE ORGANIC COMPOUNDS
EMISSIONS IN UNCAPTURED STREAM FROM
BUILDING ENCLOSURE

1. Scope and Application

1.1 Applicability. This procedure is applicable for determining the uncaptured volatile organic compounds (VOC) emissions from a building enclosure (BE). It is intended to be used in the development of liquid/gas or gas/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The total amount of uncaptured VOC emissions (F_B) from the BE is calculated as the sum of the products of the VOC content (C_{Fi}) of each uncaptured emissions point, the flow rate (Q_{Fi}) at each uncaptured emissions point, and time (Θ_F).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A gas sample is extracted from the uncaptured exhaust duct of a BE through a heated sample line and, if necessary, a glass fiber filter to a flame ionization analyzer (FIA).

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Gas VOC Concentration. A schematic of the measurement system is shown in Figure 204E-1. The main components are as follows:

4.1.1 Sample Probe. Stainless steel or equivalent. The probe shall be heated to prevent VOC condensation.

4.1.2 Calibration Valve Assembly. Three-way valve assembly at the outlet of the sample probe to direct the zero and calibration gases to the analyzer. Other methods, such as quick-connect lines, to route calibration gases to the outlet of the sample probe are acceptable.

4.1.3 Sample Line. Stainless steel or Teflon tubing to transport the sample gas to the analyzer. The sample line must be heated to prevent condensation.

4.1.4 Sample Pump. A leak-free pump, to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The components of the pump that contact the gas stream shall be constructed of stainless steel or Teflon. The sample pump must be heated to prevent condensation.

4.1.5 Sample Flow Rate Control. A sample flow rate control valve and rotameter, or equivalent, to maintain a constant sampling rate within 10 percent. The flow rate control valve and rotameter must be heated to prevent condensation. A control valve may also be located on the sample pump bypass loop to assist in controlling the sample pressure and flow rate.

4.1.6 Sample Gas Manifold. Capable of diverting a portion of the sample gas stream to the FIA, and the remainder to the bypass discharge vent. The manifold components shall be constructed of stainless steel or Teflon. If emissions are to be measured at multiple locations, the measurement system shall be designed to use separate sampling probes, lines, and pumps for each measurement location, and a common sample gas manifold and FIA. The sample gas manifold must be heated to prevent condensation.

4.1.7 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated to the Administrator's satisfaction that they would provide equally accurate measurements. The system shall be capable of meeting or exceeding the following specifications:

4.1.7.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.1.7.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.1.7.3 Calibration Error. Less than ± 5.0 percent of the calibration gas value.

4.1.7.4 Response Time. Less than 30 seconds.

4.1.8 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data. The minimum data sampling frequency for computing average or integrated values is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2 Uncaptured Emissions Volumetric Flow Rate.

4.2.1 Flow Direction Indicators. Any means of indicating inward or outward flow, such as light plastic film or paper streamers, smoke tubes, filaments, and sensory perception.

4.2.2 Method 2 or 2A Apparatus. For determining volumetric flow rate. Anemometers or similar devices calibrated according to the manufacturer's instructions may be used

when low velocities are present. Vane anemometers (Young-maximum response propeller), specialized pitots with electronic manometers (e.g., Shortridge Instruments Inc., Airdata Multimeter 860) are commercially available with measurement thresholds of 15 and 8 mpm (50 and 25 fpm), respectively.

4.2.3 Method 3 Apparatus and Reagents. For determining molecular weight of the gas stream. An estimate of the molecular weight of the gas stream may be used if approved by the Administrator.

4.2.4 Method 4 Apparatus and Reagents. For determining moisture content, if necessary.

4.3 Building Enclosure. The criteria for an acceptable BE are specified in Method 204.

5. Reagents and Standards

5.1 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.1.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H_2 /60 percent He or 40 percent H_2 /60 percent N_2 gas mixture is recommended to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.1.2 Carrier Gas. High purity air with less than 1 ppm of organic material (propane or carbon equivalent) or less than 0.1 percent of the span value, whichever is greater.

5.1.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentrations of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown to the Administrator's satisfaction that equally accurate measurements would be achieved.

5.2 Particulate Filter. An in-stack or an out-of-stack glass fiber filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated to prevent any condensation unless it

can be demonstrated that no condensation occurs.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.1.3 The system check must be conducted as specified in section 7.3.

6.2 Audits.

6.2.1 Analysis Audit Procedure. Immediately before each test, analyze an audit cylinder as described in section 7.2. The analysis audit must agree with the audit cylinder concentration within 10 percent.

6.2.2 Audit Samples and Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.2.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero- and the high-range calibration gases, and adjust the analyzer calibration to provide the proper responses. Inject the low- and mid-range gases and record the responses of the measurement system. The

calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system.

7.2 Systems Drift Checks. Select the calibration gas that most closely approximates the concentration of the captured emissions for conducting the drift checks. Introduce the zero and calibration gases at the calibration valve assembly and verify that the appropriate gas flow rate and pressure are present at the FIA. Record the measurement system responses to the zero and calibration gases. The performance of the system is acceptable if the difference between the drift check measurement and the value obtained in section 7.1 is less than 3 percent of the span value. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. Conduct a system drift check at the end of each run.

7.3 System Check. Inject the high-range calibration gas at the inlet of the sampling probe and record the response. The performance of the system is acceptable if the measurement system response is within 5 percent of the value obtained in section 7.1 for the high-range calibration gas. Conduct a system check before each test run.

8. Procedure

8.1 Preliminary Determinations. The following points are considered exhaust points and should be measured for volumetric flow rates and VOC concentrations:

8.1.1 Forced Draft Openings. Any opening in the facility with an exhaust fan. Determine the volumetric flow rate according to Method 2.

8.1.2 Roof Openings. Any openings in the roof of a facility which does not contain fans are considered to be exhaust points. Determine volumetric flow rate from these openings. Use the appropriate velocity measurement devices (e.g., propeller anemometers).

8.2 Determination of Flow Rates.

8.2.1 Measure the volumetric flow rate at all locations identified as exhaust points in section 8.1. Divide each exhaust opening into nine equal areas for rectangular openings and into eight equal areas for circular openings.

8.2.2 Measure the velocity at each site at least once every hour during each sampling run using Method 2 or 2A, if applicable, or using the low velocity instruments in section 4.2.2.

8.3 Determination of VOC Content of Uncaptured Emissions.

8.3.1 Analysis Duration. Measure the VOC responses at each uncaptured emissions point during the entire test run or, if applicable, while the process is operating. If there are multiple emissions locations, design a sampling system to allow a single FIA to be used to determine the VOC responses at all sampling locations.

8.3.2 Gas VOC Concentration.

8.3.2.1 Assemble the sample train as shown in Figure 204E-1. Calibrate the FIA and conduct a system check according to the procedures in sections 7.1 and 7.3, respectively.

8.3.2.2 Install the sample probe so that the probe is centrally located in the stack, pipe, or duct, and is sealed tightly at the stack port connection.

8.3.2.3 Inject zero gas at the calibration valve assembly. Allow the measurement system response to reach zero. Measure the system response time as the time required for the system to reach the effluent concentration after the calibration valve has been returned to the effluent sampling position.

8.3.2.4 Conduct a system check before, and a system drift check after, each sampling run according to the procedures in sections 7.2 and 7.3. If the drift check following a run indicates unacceptable performance (see section 7.3), the run is not valid. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run. The tester may elect to perform drift checks during the run, not to exceed one drift check per hour.

8.3.2.5 Verify that the sample lines, filter, and pump temperatures are $120 \pm 5^\circ\text{C}$.

8.3.2.6 Begin sampling at the start of the test period and continue to sample during the entire run. Record the starting and ending times, and any required process information, as appropriate. If multiple emission locations are sampled using a single FIA, sample at each location for the same amount of time (e.g., 2 minutes) and continue to switch from one location to another for the entire test run. Be sure that total sampling time at each location is the same at the end of the test run. Collect at least four separate measurements from each sample point during each hour of testing. Disregard the response measurements at each sampling location until 2 times the response time of the measurement system has elapsed. Continue sampling for at least 1 minute, and record the concentration measurements.

8.4 Alternative Procedure. The direct interface sampling and analysis procedure described in section 7.2 of Method 18 may be

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used to determine the gas VOC concentration. The system must be designed to collect and analyze at least one sample every 10 minutes. If the alternative procedure is used to determine the VOC concentration of the uncaptured emissions in a gas/gas protocol, it must also be used to determine the VOC concentration of the captured emissions. If a tester wishes to conduct a liquid/gas protocol using a gas chromatograph, the tester must use Method 204F for the liquid stream. A gas chromatograph is not an acceptable alternative to the FIA in Method 204A.

9. Data Analysis and Calculations

9.1 Nomenclature.

C_{DH} =average measured concentration for the drift check calibration gas, ppm propane.

C_{DO} =average system drift check concentration for zero concentration gas, ppm propane.

C_{Fj} =corrected average VOC concentration of uncaptured emissions at point j, ppm propane.

C_H =actual concentration of the drift check calibration gas, ppm propane.

C_j =uncorrected average VOC concentration measured at point j, ppm propane.

F_B =total VOC content of uncaptured emissions from the building, kg.

$K_1=1.830 \times 10^{-6}$ kg/(m³-ppm).

n =number of measurement points.

Q_{Fj} =average effluent volumetric flow rate corrected to standard conditions at uncaptured emissions point j, m³/min.

θ_F =total duration of CE sampling run, min.

9.2 Calculations

9.2.1 Total VOC Uncaptured Emissions from the Building.

$$F_B = \sum_{j=1}^n C_{Fj} Q_{Fj} \theta_F K_1 \quad \text{Eq. 204E-1}$$

9.2.2 VOC Concentration of the Uncaptured Emissions at Point j.

$$C_{Fj} = (C_j - C_{DO}) \frac{C_H}{C_{DH} - C_{DO}} \quad \text{Eq. 204E-2}$$

10. Method Performance

The measurement uncertainties are estimated for each uncaptured emissions point as follows: $Q_{Fj}=\pm 10.0$ percent and $C_{Fj}=\pm 5.0$ percent. Based on these numbers, the probable uncertainty for F_B is estimated at about ± 11.2 percent.

11. Diagrams

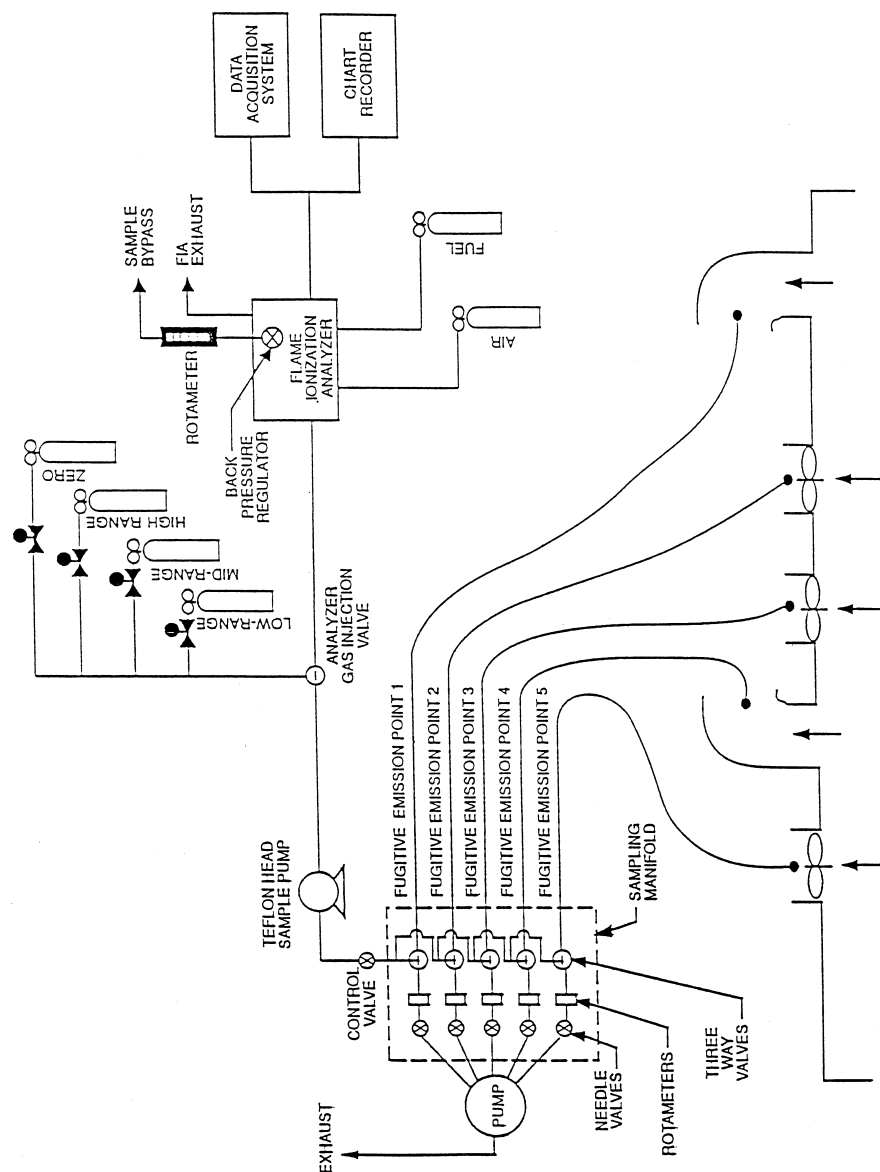


Figure 204E-1. Fugitive emissions measurement system.

METHOD 204F—VOLATILE ORGANIC COMPOUNDS CONTENT IN LIQUID INPUT STREAM (DISTILLATION APPROACH)

1. Introduction

1.1 Applicability. This procedure is applicable for determining the input of volatile organic compounds (VOC). It is intended to

be used as a segment in the development of liquid/gas protocols for determining VOC capture efficiency (CE) for surface coating and printing operations.

1.2 Principle. The amount of VOC introduced to the process (L) is the sum of the products of the weight (W) of each VOC containing liquid (ink, paint, solvent, etc.) used,

and its VOC content (V), corrected for a response factor (RF).

1.3 Sampling Requirements. A CE test shall consist of at least three sampling runs. Each run shall cover at least one complete production cycle, but shall be at least 3 hours long. The sampling time for each run need not exceed 8 hours, even if the production cycle has not been completed. Alternative sampling times may be used with the approval of the Administrator.

2. Summary of Method

A sample of each coating used is distilled to separate the VOC fraction. The distillate is used to prepare a known standard for analysis by an flame ionization analyzer (FIA), calibrated against propane, to determine its RF.

3. Safety

Because this procedure is often applied in highly explosive areas, caution and care should be exercised in choosing, installing, and using the appropriate equipment.

4. Equipment and Supplies

Mention of trade names or company products does not constitute endorsement. All gas concentrations (percent, ppm) are by volume, unless otherwise noted.

4.1 Liquid Weight.

4.1.1 Balances/Digital Scales. To weigh drums of VOC containing liquids to within 0.2 lb or 1.0 percent of the total weight of VOC liquid used.

4.1.2 Volume Measurement Apparatus (Alternative). Volume meters, flow meters, density measurement equipment, etc., as needed to achieve the same accuracy as direct weight measurements.

4.2 Response Factor Determination (FIA Technique). The VOC distillation system and Tedlar gas bag generation system apparatuses are shown in Figures 204F-1 and 204F-2, respectively. The following equipment is required:

4.2.1 Sample Collection Can. An appropriately-sized metal can to be used to collect VOC containing materials. The can must be constructed in such a way that it can be grounded to the coating container.

4.2.2 Needle Valves. To control gas flow.

4.2.3 Regulators. For calibration, dilution, and sweep gas cylinders.

4.2.4 Tubing and Fittings. Teflon and stainless steel tubing and fittings with diameters, lengths, and sizes determined by the connection requirements of the equipment.

4.2.5 Thermometer. Capable of measuring the temperature of the hot water and oil baths to within 1 °C.

4.2.6 Analytical Balance. To measure ± 0.01 mg.

4.2.7 Microliter Syringe. 10- μ l size.

4.2.8 Vacuum Gauge or Manometer. 0- to 760-mm (0- to 30-in.) Hg U-Tube manometer or vacuum gauge.

4.2.9 Hot Oil Bath, With Stirring Hot Plate. Capable of heating and maintaining a distillation vessel at 110 ± 3 °C.

4.2.10 Ice Water Bath. To cool the distillation flask.

4.2.11 Vacuum/Water Aspirator. A device capable of drawing a vacuum to within 20 mm Hg from absolute.

4.2.12 Rotary Evaporator System. Complete with folded inner coil, vertical style condenser, rotary speed control, and Teflon sweep gas delivery tube with valved inlet. Buchi Rotavapor or equivalent.

4.2.13 Ethylene Glycol Cooling/Circulating Bath. Capable of maintaining the condenser coil fluid at -10 °C.

4.2.14 Dry Gas Meter (DGM). Capable of measuring the dilution gas volume within 2 percent, calibrated with a spirometer or bubble meter, and equipped with a temperature gauge capable of measuring temperature within 3 °C.

4.2.15 Activated Charcoal/Mole Sieve Trap. To remove any trace level of organics picked up from the DGM.

4.2.16 Gas Coil Heater. Sufficient length of 0.125-inch stainless steel tubing to allow heating of the dilution gas to near the water bath temperature before entering the volatilization vessel.

4.2.17 Water Bath, With Stirring Hot Plate. Capable of heating and maintaining a volatilization vessel and coil heater at a temperature of 100 ± 5 °C.

4.2.18 Volatilization Vessel. 50-ml midjet impinger fitted with a septum top and loosely filled with glass wool to increase the volatilization surface.

4.2.19 Tedlar Gas Bag. Capable of holding 30 liters of gas, flushed clean with zero air, leak tested, and evacuated.

4.2.20 Organic Concentration Analyzer. An FIA with a span value of 1.5 times the expected concentration as propane; however, other span values may be used if it can be demonstrated that they would provide equally accurate measurements. The FIA instrument should be the same instrument used in the gaseous analyses adjusted with the same fuel, combustion air, and sample back-pressure (flow rate) settings. The system shall be capable of meeting or exceeding the following specifications:

4.2.20.1 Zero Drift. Less than ± 3.0 percent of the span value.

4.2.20.2 Calibration Drift. Less than ± 3.0 percent of the span value.

4.2.20.3 Calibration Error. Less than ± 3.0 percent of the calibration gas value.

4.2.21 Integrator/Data Acquisition System. An analog or digital device or computerized data acquisition system used to integrate the FIA response or compute the average response and record measurement data.

The minimum data sampling frequency for computing average or integrated value is one measurement value every 5 seconds. The device shall be capable of recording average values at least once per minute.

4.2.22 Chart Recorder (Optional). A chart recorder or similar device is recommended to provide a continuous analog display of the measurement results during the liquid sample analysis.

5. Reagents and Standards

5.1 Zero Air. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater. Used to supply dilution air for making the Tedlar bag gas samples.

5.2 THC Free N₂. High purity N₂ with less than 1 ppm THC. Used as sweep gas in the rotary evaporator system.

5.3 Calibration and Other Gases. Gases used for calibration, fuel, and combustion air (if required) are contained in compressed gas cylinders. All calibration gases shall be traceable to National Institute of Standards and Technology standards and shall be certified by the manufacturer to ± 1 percent of the tag value. Additionally, the manufacturer of the cylinder should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change more than ± 2 percent from the certified value. For calibration gas values not generally available, dilution systems calibrated using Method 205 may be used. Alternative methods for preparing calibration gas mixtures may be used with the approval of the Administrator.

5.3.1 Fuel. The FIA manufacturer's recommended fuel should be used. A 40 percent H₂/60 percent He, or 40 percent H₂/60 percent N₂ mixture is recommended to avoid fuels with oxygen to avoid an oxygen synergism effect that reportedly occurs when oxygen concentration varies significantly from a mean value. Other mixtures may be used provided the tester can demonstrate to the Administrator that there is no oxygen synergism effect.

5.3.2 Combustion Air. High purity air with less than 1 ppm of organic material (as propane) or less than 0.1 percent of the span value, whichever is greater.

5.3.3 FIA Linearity Calibration Gases. Low-, mid-, and high-range gas mixture standards with nominal propane concentration of 20-30, 45-55, and 70-80 percent of the span value in air, respectively. Other calibration values and other span values may be used if it can be shown that equally accurate measurements would be achieved.

5.3.4 System Calibration Gas. Gas mixture standard containing propane in air, approximating the VOC concentration expected for the Tedlar gas bag samples.

6. Quality Control

6.1 Required instrument quality control parameters are found in the following sections:

6.1.1 The FIA system must be calibrated as specified in section 7.1.

6.1.2 The system drift check must be performed as specified in section 7.2.

6.2 Precision Control. A minimum of one sample in each batch must be distilled and analyzed in duplicate as a precision control. If the results of the two analyses differ by more than ± 10 percent of the mean, then the system must be reevaluated and the entire batch must be redistilled and analyzed.

6.3 Audits.

6.3.1 Audit Procedure. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit sample. If this condition is met, auditing of subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

6.3.2 Audit Samples. Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (STAC) (MD-77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711 or by calling the STAC at (919) 541-7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

6.3.3 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency, and a second copy to the STAC. The EPA Regional Office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

7. Calibration and Standardization

7.1 FIA Calibration and Linearity Check. Make necessary adjustments to the air and fuel supplies for the FIA and ignite the burner. Allow the FIA to warm up for the period recommended by the manufacturer. Inject a calibration gas into the measurement system and adjust the back-pressure regulator to the value required to achieve the flow rates specified by the manufacturer. Inject the zero and the high-range calibration gases and adjust the analyzer calibration to provide the proper responses. Inject the low and mid-range gases and record the responses of the measurement system. The calibration and linearity of the system are acceptable if the responses for all four gases are within 5 percent of the respective gas values. If the performance of the system is not acceptable, repair or adjust the system and repeat the linearity check. Conduct a calibration and linearity check after assembling the analysis system and after a major change is made to the system. A calibration curve consisting of zero gas and two calibration levels must be performed at the beginning and end of each batch of samples.

7.2 Systems Drift Checks. After each sample, repeat the system calibration checks in section 7.1 before any adjustments to the FIA or measurement system are made. If the zero or calibration drift exceeds ± 3 percent of the span value, discard the result and repeat the analysis. Alternatively, recalibrate the FIA as in section 7.1 and report the results using both sets of calibration data (i.e., data determined prior to the test period and data determined following the test period). The data that results in the lowest CE value shall be reported as the results for the test run.

8. Procedures

8.1 Determination of Liquid Input Weight

8.1.1 Weight Difference. Determine the amount of material introduced to the process as the weight difference of the feed material before and after each sampling run. In determining the total VOC containing liquid usage, account for: (a) The initial (beginning) VOC containing liquid mixture; (b) any solvent added during the test run; (c) any coating added during the test run; and (d) any residual VOC containing liquid mixture remaining at the end of the sample run.

8.1.1.1 Identify all points where VOC containing liquids are introduced to the process. To obtain an accurate measurement of VOC containing liquids, start with an empty fountain (if applicable). After completing the run, drain the liquid in the fountain back into the liquid drum (if possible), and weigh the drum again. Weigh the VOC containing liquids to ± 0.5 percent of the total weight (full) or ± 1.0 percent of the total weight of VOC containing liquid used during the sam-

ple run, whichever is less. If the residual liquid cannot be returned to the drum, drain the fountain into a preweighed empty drum to determine the final weight of the liquid.

8.1.1.2 If it is not possible to measure a single representative mixture, then weigh the various components separately (e.g., if solvent is added during the sampling run, weigh the solvent before it is added to the mixture). If a fresh drum of VOC containing liquid is needed during the run, then weigh both the empty drum and fresh drum.

8.1.2 Volume Measurement (Alternative). If direct weight measurements are not feasible, the tester may use volume meters and flow rate meters (and density measurements) to determine the weight of liquids used if it can be demonstrated that the technique produces results equivalent to the direct weight measurements. If a single representative mixture cannot be measured, measure the components separately.

8.2 Determination of VOC Content in Input Liquids

8.2.1 Collection of Liquid Samples.

8.2.1.1 Collect a 1-pint or larger sample of the VOC containing liquid mixture at each application location at the beginning and end of each test run. A separate sample should be taken of each VOC containing liquid added to the application mixture during the test run. If a fresh drum is needed during the sampling run, then obtain a sample from the fresh drum.

8.2.1.2 When collecting the sample, ground the sample container to the coating drum. Fill the sample container as close to the rim as possible to minimize the amount of headspace.

8.2.1.3 After the sample is collected, seal the container so the sample cannot leak out or evaporate.

8.2.1.4 Label the container to identify clearly the contents.

8.2.2 Distillation of VOC.

8.2.2.1 Assemble the rotary evaporator as shown in Figure 204F-1.

8.2.2.2 Leak check the rotary evaporation system by aspirating a vacuum of approximately 20 mm Hg from absolute. Close up the system and monitor the vacuum for approximately 1 minute. If the vacuum falls more than 25 mm Hg in 1 minute, repair leaks and repeat. Turn off the aspirator and vent vacuum.

8.2.2.3 Deposit approximately 20 ml of sample (inks, paints, etc.) into the rotary evaporation distillation flask.

8.2.2.4 Install the distillation flask on the rotary evaporator.

8.2.2.5 Immerse the distillate collection flask into the ice water bath.

8.2.2.6 Start rotating the distillation flask at a speed of approximately 30 rpm.

8.2.2.7 Begin heating the vessel at a rate of 2 to 3 °C per minute.

8.2.2.8 After the hot oil bath has reached a temperature of 50 °C or pressure is evident on the mercury manometer, turn on the aspirator and gradually apply a vacuum to the evaporator to within 20 mm Hg of absolute. Care should be taken to prevent material burping from the distillation flask.

8.2.2.9 Continue heating until a temperature of 110 °C is achieved and maintain this temperature for at least 2 minutes, or until the sample has dried in the distillation flask.

8.2.2.10 Slowly introduce the N₂ sweep gas through the purge tube and into the distillation flask, taking care to maintain a vacuum of approximately 400-mm Hg from absolute.

8.2.2.11 Continue sweeping the remaining solvent VOC from the distillation flask and condenser assembly for 2 minutes, or until all traces of condensed solvent are gone from the vessel. Some distillate may remain in the still head. This will not affect solvent recovery ratios.

8.2.2.12 Release the vacuum, disassemble the apparatus and transfer the distillate to a labeled, sealed vial.

8.2.3 Preparation of VOC standard bag sample.

8.2.3.1 Assemble the bag sample generation system as shown in Figure 204F-2 and bring the water bath up to near boiling temperature.

8.2.3.2 Inflate the Tedlar bag and perform a leak check on the bag.

8.2.3.3 Evacuate the bag and close the bag inlet valve.

8.2.3.4 Record the current barometric pressure.

8.2.3.5 Record the starting reading on the dry gas meter, open the bag inlet valve, and start the dilution zero air flowing into the Tedlar bag at approximately 2 liters per minute.

8.2.3.6 The bag sample VOC concentration should be similar to the gaseous VOC concentration measured in the gas streams. The amount of liquid VOC required can be approximated using equations in section 9.2. Using Equation 204F-4, calculate C_{VOC} by assuming RF is 1.0 and selecting the desired gas concentration in terms of propane, C_{C3}. Assuming B_V is 20 liters, M_L, the approximate amount of liquid to be used to prepare the bag gas sample, can be calculated using Equation 204F-2.

8.2.3.7 Quickly withdraw an aliquot of the approximate amount calculated in section 8.2.3.6 from the distillate vial with the microliter syringe and record its weight from the analytical balance to the nearest 0.01 mg.

8.2.3.8 Inject the contents of the syringe through the septum of the volatilization vessel into the glass wool inside the vessel.

8.2.3.9 Reweigh and record the tare weight of the now empty syringe.

8.2.3.10 Record the pressure and temperature of the dilution gas as it is passed through the dry gas meter.

8.2.3.11 After approximately 20 liters of dilution gas have passed into the Tedlar bag, close the valve to the dilution air source and record the exact final reading on the dry gas meter.

8.2.3.12 The gas bag is then analyzed by FIA within 1 hour of bag preparation in accordance with the procedure in section 8.2.4.

8.2.4 Determination of VOC response factor.

8.2.4.1 Start up the FIA instrument using the same settings as used for the gaseous VOC measurements.

8.2.4.2 Perform the FIA analyzer calibration and linearity checks according to the procedure in section 7.1. Record the responses to each of the calibration gases and the back-pressure setting of the FIA.

8.2.4.3 Connect the Tedlar bag sample to the FIA sample inlet and record the bag concentration in terms of propane. Continue the analyses until a steady reading is obtained for at least 30 seconds. Record the final reading and calculate the RF.

8.2.5 Determination of coating VOC content as VOC (V_U).

8.2.5.1 Determine the VOC content of the coatings used in the process using EPA Method 24 or 24A as applicable.

9. Data Analysis and Calculations

9.1. Nomenclature.

B_V=Volume of bag sample volume, liters.

C_{C3}=Concentration of bag sample as propane, mg/liter.

C_{VOC}=Concentration of bag sample as VOC, mg/liter.

K=0.00183 mg propane/(liter-ppm propane)

L=Total VOC content of liquid input, kg propane.

M_L=Mass of VOC liquid injected into the bag, mg.

M_V=Volume of gas measured by DGM, liters.

P_M=Absolute DGM gas pressure, mm Hg.

P_{STD}=Standard absolute pressure, 760 mm Hg.

R_{C3}=FIA reading for bag gas sample, ppm propane.

RF=Response factor for VOC in liquid, weight VOC/weight propane.

RF_J=Response factor for VOC in liquid J, weight VOC/weight propane.

T_M=DGM temperature, °K.

T_{STD}=Standard absolute temperature, 293 °K.

V_U=Initial VOC weight fraction of VOC liquid J.

V_{FJ}=Final VOC weight fraction of VOC liquid J.

V_{AJ}=VOC weight fraction of VOC liquid J added during the run.

W_U=Weight of VOC containing liquid J at beginning of run, kg.

W_{FJ}=Weight of VOC containing liquid J at end of run, kg.

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W_{AJ} =Weight of VOC containing liquid J added during the run, kg.

9.2 Calculations.**9.2.1 Bag sample volume.**

$$B_V = \frac{M_V T_{STD} P_M}{T_M P_{STD}} \quad \text{Eq. 204F-1}$$

9.2.2 Bag sample VOC concentration.

$$C_{VOC} = \frac{M_L}{B_V} \quad \text{Eq. 204F-2}$$

9.2.3 Bag sample VOC concentration as propane.

$$C_{C_3} = R_{C_3} K \quad \text{Eq. 204F-3}$$

9.2.4 Response Factor.

$$RF = \frac{C_{VOC}}{C_{C_3}} \quad \text{Eq. 204F-4}$$

9.2.5 Total VOC Content of the Input VOC Containing Liquid.

$$L = \sum_{j=1}^n \frac{V_{rj} W_{rj}}{RF_j} - \sum_{j=1}^n \frac{V_{Fj} W_{Fj}}{RF_j} + \sum_{j=1}^n \frac{V_{Aj} W_{Aj}}{RF_j} \quad \text{Eq. 204F-5}$$

10. Diagrams

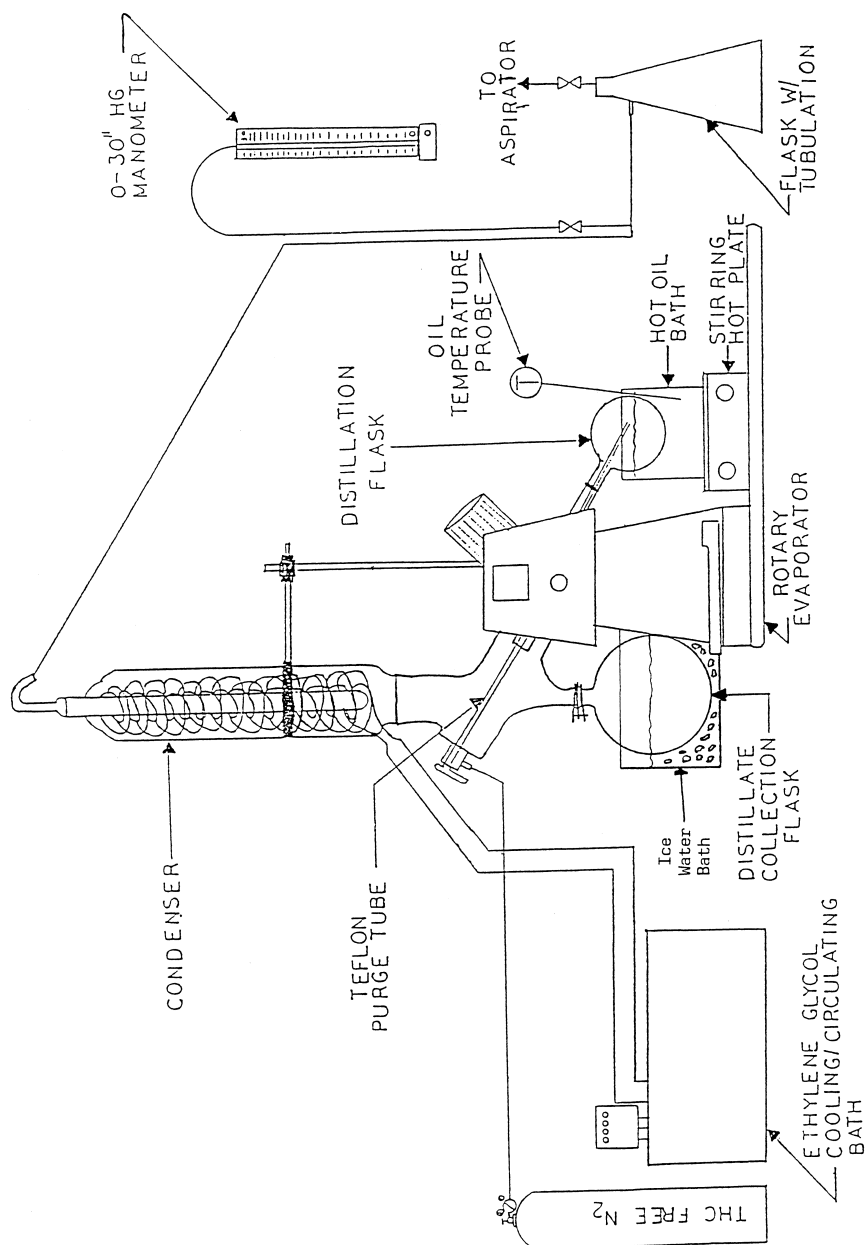


Figure 204F-1. VOC distillation system apparatus.

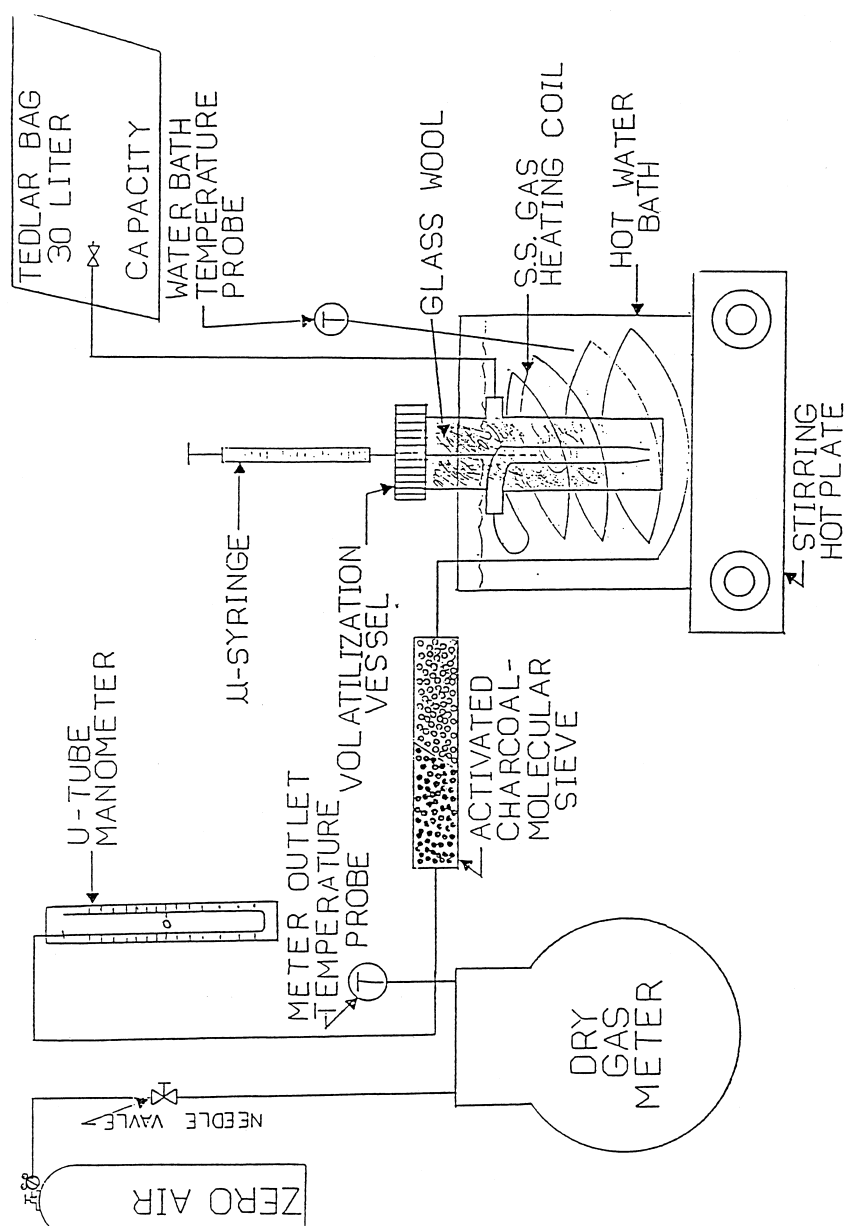


Figure 204F-2. Tedlar gas bag generation system apparatus.

METHOD 205—VERIFICATION OF GAS DILUTION SYSTEMS FOR FIELD INSTRUMENT CALIBRATIONS

1. Introduction

1.1 Applicability. A gas dilution system can provide known values of calibration gases through controlled dilution of high-level calibration gases with an appropriate dilution gas. The instrumental test methods in 40 CFR part 60—e.g., Methods 3A, 6C, 7E, 10, 15, 16, 20, 25A and 25B—require on-site, multi-point calibration using gases of known concentrations. A gas dilution system that produces known low-level calibration gases from high-level calibration gases, with a degree of confidence similar to that for Protocol¹ gases, may be used for compliance tests in lieu of multiple calibration gases when the gas dilution system is demonstrated to meet the requirements of this method. The Administrator may also use a gas dilution system in order to produce a wide range of Cylinder Gas Audit concentrations when conducting performance specifications according to appendix F, 40 CFR part 60. As long as the acceptance criteria of this method are met, this method is applicable to gas dilution systems using any type of dilution technology, not solely the ones mentioned in this method.

1.2 Principle. The gas dilution system shall be evaluated on one analyzer once during each field test. A precalibrated analyzer is chosen, at the discretion of the source owner or operator, to demonstrate that the gas dilution system produces predictable gas concentrations spanning a range of concentrations. After meeting the requirements of this method, the remaining analyzers may be calibrated with the dilution system in accordance to the requirements of the applicable method for the duration of the field test. In Methods 15 and 16, 40 CFR part 60, appendix A, reactive compounds may be lost in the gas dilution system. Also, in Methods 25A and 25B, 40 CFR part 60, appendix A, calibration with target compounds other than propane is allowed. In these cases, a laboratory evaluation is required once per year in order to assure the Administrator that the system will dilute these reactive gases without significant loss.

NOTE: The laboratory evaluation is required only if the source owner or operator plans to utilize the dilution system to prepare gases mentioned above as being reactive.

2. Specifications

2.1 Gas Dilution System. The gas dilution system shall produce calibration gases whose measured values are within ± 2 percent of the predicted values. The predicted values are calculated based on the certified concentration of the supply gas (Protocol gases, when

available, are recommended for their accuracy) and the gas flow rates (or dilution ratios) through the gas dilution system.

2.1.1 The gas dilution system shall be recalibrated once per calendar year using NIST-traceable primary flow standards with an uncertainty ≤ 0.25 percent. A label shall be affixed at all times to the gas dilution system listing the date of the most recent calibration, the due date for the next calibration, and the person or manufacturer who carried out the calibration. Follow the manufacturer's instructions for the operation and use of the gas dilution system. A copy of the manufacturer's instructions for the operation of the instrument, as well as the most recent recalibration documentation shall be made available for the Administrator's inspection upon request.

2.1.2 Some manufacturers of mass flow controllers recommend that flow rates below 10 percent of flow controller capacity be avoided; check for this recommendation and follow the manufacturer's instructions. One study has indicated that silicone oil from a positive displacement pump produces an interference in SO₂ analyzers utilizing ultraviolet fluorescence; follow laboratory procedures similar to those outlined in Section 3.1 in order to demonstrate the significance of any resulting effect on instrument performance.

2.2 High-Level Supply Gas. An EPA Protocol calibration gas is recommended, due to its accuracy, as the high-level supply gas.

2.3 Mid-Level Supply Gas. An EPA Protocol gas shall be used as an independent check of the dilution system. The concentration of the mid-level supply gas shall be within 10 percent of one of the dilution levels tested in Section 3.2.

3. Performance Tests

3.1 Laboratory Evaluation (Optional). If the gas dilution system is to be used to formulate calibration gases with reactive compounds (Test Methods 15, 16, and 25A/25B (only if using a calibration gas other than propane during the field test) in 40 CFR part 60, appendix A), a laboratory certification must be conducted once per calendar year for each reactive compound to be diluted. In the laboratory, carry out the procedures in Section 3.2 on the analyzer required in each respective test method to be laboratory certified (15, 16, or 25A and 25B for compounds other than propane). For each compound in which the gas dilution system meets the requirements in Section 3.2, the source must provide the laboratory certification data for the field test and in the test report.

3.2 Field Evaluation (Required). The gas dilution system shall be evaluated at the test site with an analyzer or monitor chosen by the source owner or operator. It is recommended that the source owner or operator choose a precalibrated instrument with a

high level of precision and accuracy for the purposes of this test. This method is not meant to replace the calibration requirements of test methods. In addition to the requirements in this method, all the calibration requirements of the applicable test method must also be met.

3.2.1 Prepare the gas dilution system according to the manufacturer's instructions. Using the high-level supply gas, prepare, at a minimum, two dilutions within the range of each dilution device utilized in the dilution system (unless, as in critical orifice systems, each dilution device is used to make only one dilution; in that case, prepare one dilution for each dilution device). Dilution device in this method refers to each mass flow controller, critical orifice, capillary tube, positive displacement pump, or any other device which is used to achieve gas dilution.

3.2.2 Calculate the predicted concentration for each of the dilutions based on the flow rates through the gas dilution system (or the dilution ratios) and the certified concentration of the high-level supply gas.

3.2.3 Introduce each of the dilutions from Section 3.2.1 into the analyzer or monitor one at a time and determine the instrument response for each of the dilutions.

3.2.4 Repeat the procedure in Section 3.2.3 two times, i.e., until three injections are made at each dilution level. Calculate the average instrument response for each triplicate injection at each dilution level. No single injection shall differ by more than ± 2 percent from the average instrument response for that dilution.

3.2.5 For each level of dilution, calculate the difference between the average concentration output recorded by the analyzer and the predicted concentration calculated in Section 3.2.2. The average concentration output from the analyzer shall be within ± 2 percent of the predicted value.

3.2.6 Introduce the mid-level supply gas directly into the analyzer, bypassing the gas dilution system. Repeat the procedure twice more, for a total of three mid-level supply gas injections. Calculate the average analyzer output concentration for the mid-level supply gas. The difference between the certified concentration of the mid-level supply gas and the average instrument response shall be within ± 2 percent.

3.3 If the gas dilution system meets the criteria listed in Section 3.2, the gas dilution system may be used throughout that field test. If the gas dilution system fails any of the criteria listed in Section 3.2, and the tester corrects the problem with the gas dilution system, the procedure in Section 3.2 must be repeated in its entirety and all the criteria in Section 3.2 must be met in order for the gas dilution system to be utilized in the test.

4. References

1. "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards," EPA-600/R93/224, Revised September 1993.

[55 FR 14249, Apr. 17, 1990; 55 FR 24687, June 18, 1990, as amended at 55 FR 37606, Sept. 12, 1990; 56 FR 6278, Feb. 15, 1991; 56 FR 65435, Dec. 17, 1991; 60 FR 28054, May 30, 1995; 62 FR 32502, June 16, 1997]

APPENDICES N-O [RESERVED]

APPENDIX P TO PART 51—MINIMUM EMISSION MONITORING REQUIREMENTS

1.0 *Purpose.* This appendix P sets forth the minimum requirements for continuous emission monitoring and recording that each State Implementation Plan must include in order to be approved under the provisions of 40 CFR 51.165(b). These requirements include the source categories to be affected; emission monitoring, recording, and reporting requirements for those sources; performance specifications for accuracy, reliability, and durability of acceptable monitoring systems; and techniques to convert emission data to units of the applicable State emission standard. Such data must be reported to the State as an indication of whether proper maintenance and operating procedures are being utilized by source operators to maintain emission levels at or below emission standards. Such data may be used directly or indirectly for compliance determination or any other purpose deemed appropriate by the State. Though the monitoring requirements are specified in detail, States are given some flexibility to resolve difficulties that may arise during the implementation of these regulations.

1.1 *Applicability.* The State plan shall require the owner or operator of an emission source in a category listed in this appendix to: (1) Install, calibrate, operate, and maintain all monitoring equipment necessary for continuously monitoring the pollutants specified in this appendix for the applicable source category; and (2) complete the installation and performance tests of such equipment and begin monitoring and recording within 18 months of plan approval or promulgation. The source categories and the respective monitoring requirements are listed below.

1.1.1 Fossil fuel-fired steam generators, as specified in paragraph 2.1 of this appendix, shall be monitored for opacity, nitrogen oxides emissions, sulfur dioxide emissions, and oxygen or carbon dioxide.

1.1.2 Fluid bed catalytic cracking unit catalyst regenerators, as specified in paragraph 2.4 of this appendix, shall be monitored for opacity.

1.1.3 Sulfuric acid plants, as specified in paragraph 2.3 of this appendix, shall be monitored for sulfur dioxide emissions.

1.1.4 Nitric acid plants, as specified in paragraph 2.2 of this appendix, shall be monitored for nitrogen oxides emissions.

1.2 *Exemptions.* The States may include provisions within their regulations to grant exemptions from the monitoring requirements of paragraph 1.1 of this appendix for any source which is:

1.2.1 Subject to a new source performance standard promulgated in 40 CFR part 60 pursuant to section 111 of the Clean Air Act; or

1.2.2 not subject to an applicable emission standard of an approved plan; or

1.2.3 scheduled for retirement within 5 years after inclusion of monitoring requirements for the source in appendix P, provided that adequate evidence and guarantees are provided that clearly show that the source will cease operations prior to such date.

1.3 *Extensions.* States may allow reasonable extensions of the time provided for installation of monitors for facilities unable to meet the prescribed timeframe (i.e., 18 months from plan approval or promulgation) provided the owner or operator of such facility demonstrates that good faith efforts have been made to obtain and install such devices within such prescribed timeframe.

1.4 *Monitoring System Malfunction.* The State plan may provide a temporary exemption from the monitoring and reporting requirements of this appendix during any period of monitoring system malfunction, provided that the source owner or operator shows, to the satisfaction of the State, that the malfunction was unavoidable and is being repaired as expeditiously as practicable.

2.0 *Minimum Monitoring Requirement.* States must, as a minimum, require the sources listed in paragraph 1.1 of this appendix to meet the following basic requirements.

2.1 *Fossil fuel-fired steam generators.* Each fossil fuel-fired steam generator, except as provided in the following subparagraphs, with an annual average capacity factor of greater than 30 percent, as reported to the Federal Power Commission for calendar year 1974, or as otherwise demonstrated to the State by the owner or operator, shall conform with the following monitoring requirements when such facility is subject to an emission standard of an applicable plan for the pollutant in question.

2.1.1 A continuous monitoring system for the measurement of opacity which meets the performance specifications of paragraph 3.1.1 of this appendix shall be installed, calibrated, maintained, and operated in accordance with the procedures of this appendix by the owner or operator of any such steam generator of greater than 250 million BTU per hour heat input except where:

2.1.1.1 gaseous fuel is the only fuel burned, or

2.1.1.2 oil or a mixture of gas and oil are the only fuels burned and the source is able to comply with the applicable particulate matter and opacity regulations without utilization of particulate matter collection equipment, and where the source has never been found, through any administrative or judicial proceedings, to be in violation of any visible emission standard of the applicable plan.

2.1.2 A continuous monitoring system for the measurement of sulfur dioxide which meets the performance specifications of paragraph 3.1.3 of this appendix shall be installed, calibrated, maintained, and operated on any fossil fuel-fired steam generator of greater than 250 million BTU per hour heat input which has installed sulfur dioxide pollutant control equipment.

2.1.3 A continuous monitoring system for the measurement of nitrogen oxides which meets the performance specification of paragraph 3.1.2 of this appendix shall be installed, calibrated, maintained, and operated on fossil fuel-fired steam generators of greater than 1000 million BTU per hour heat input when such facility is located in an Air Quality Control Region where the Administrator has specifically determined that a control strategy for nitrogen dioxide is necessary to attain the national standards, unless the source owner or operator demonstrates during source compliance tests as required by the State that such a source emits nitrogen oxides at levels 30 percent or more below the emission standard within the applicable plan.

2.1.4 A continuous monitoring system for the measurement of the percent oxygen or carbon dioxide which meets the performance specifications of paragraphs 3.1.4 or 3.1.5 of this appendix shall be installed, calibrated, operated, and maintained on fossil fuel-fired steam generators where measurements of oxygen or carbon dioxide in the flue gas are required to convert either sulfur dioxide or nitrogen oxides continuous emission monitoring data, or both, to units of the emission standard within the applicable plan.

2.2 *Nitric acid plants.* Each nitric acid plant of greater than 300 tons per day production capacity, the production capacity being expressed as 100 percent acid, located in an Air Quality Control Region where the Administrator has specifically determined that a control strategy for nitrogen dioxide is necessary to attain the national standard shall install, calibrate, maintain, and operate a continuous monitoring system for the measurement of nitrogen oxides which meets the performance specifications of paragraph 3.1.2 for each nitric acid producing facility within such plant.

2.3 Sulfuric acid plants. Each Sulfuric acid plant of greater than 300 tons per day production capacity, the production being expressed as 100 percent acid, shall install, calibrate, maintain and operate a continuous monitoring system for the measurement of sulfur dioxide which meets the performance specifications of paragraph 3.1.3 for each sulfuric acid producing facility within such plant.

2.4 Fluid bed catalytic cracking unit catalyst regenerators at petroleum refineries. Each catalyst regenerator for fluid bed catalytic cracking units of greater than 20,000 barrels per day fresh feed capacity shall install, calibrate, maintain, and operate a continuous monitoring system for the measurement of opacity which meets the performance specifications of paragraph 3.1.1.

3.0 Minimum specifications. All State plans shall require owners or operators of monitoring equipment installed to comply with this appendix, except as provided in paragraph 3.2, to demonstrate compliance with the following performance specifications.

3.1 Performance specifications. The performance specifications set forth in appendix B of part 60 are incorporated herein by reference, and shall be used by States to determine acceptability of monitoring equipment installed pursuant to this appendix except that (1) where reference is made to the "Administrator" in appendix B, part 60, the term *State* should be inserted for the purpose of this appendix (e.g., in Performance Specification 1, 1.2, " * * * monitoring systems subject to approval by the *Administrator*," should be interpreted as, " * * * monitoring systems subject to approval by the *State*"), and (2) where reference is made to the "Reference Method" in appendix B, part 60, the State may allow the use of either the State approved reference method or the Federally approved reference method as published in part 60 of this chapter. The Performance Specifications to be used with each type of monitoring system are listed below.

3.1.1 Continuous monitoring systems for measuring opacity shall comply with Performance Specification 1.

3.1.2 Continuous monitoring systems for measuring nitrogen oxides shall comply with Performance Specification 2.

3.1.3 Continuous monitoring systems for measuring sulfur dioxide shall comply with Performance Specification 2.

3.1.4 Continuous monitoring systems for measuring oxygen shall comply with Performance Specification 3.

3.1.5 Continuous monitoring systems for measuring carbon dioxide shall comply with Performance Specification 3.

3.2 Exemptions. Any source which has purchased an emission monitoring system(s) prior to September 11, 1974, may be exempt from meeting such test procedures prescribed in appendix B of part 60 for a period

not to exceed five years from plan approval or promulgation.

3.3 Calibration Gases. For nitrogen oxides monitoring systems installed on fossil fuel-fired steam generators the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60) shall be nitric oxide (NO). For nitrogen oxides monitoring systems, installed on nitric acid plants the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60 of this chapter) shall be nitrogen dioxide (NO₂). These gases shall also be used for daily checks under paragraph 3.7 of this appendix as applicable. For sulfur dioxide monitoring systems installed on fossil fuel-fired steam generators or sulfuric acid plants the pollutant gas used to prepare calibration gas mixtures (Section 2.1, Performance Specification 2, appendix B, part 60 of this chapter) shall be sulfur dioxide (SO₂). Span and zero gases should be traceable to National Bureau of Standards reference gases whenever these reference gases are available. Every six months from date of manufacture, span and zero gases shall be re-analyzed by conducting triplicate analyses using the reference methods in appendix A, part 60 of this chapter as follows: for sulfur dioxide, use Reference Method 6; for nitrogen oxides, use Reference Method 7; and for carbon dioxide or oxygen, use Reference Method 3. The gases may be analyzed at less frequent intervals if longer shelf lives are guaranteed by the manufacturer.

3.4 Cycling times. Cycling times include the total time a monitoring system requires to sample, analyze and record an emission measurement.

3.4.1 Continuous monitoring systems for measuring opacity shall complete a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 10-second period.

3.4.2 Continuous monitoring systems for measuring oxides of nitrogen, carbon dioxide, oxygen, or sulfur dioxide shall complete a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 15-minute period.

3.5 Monitor location. State plans shall require all continuous monitoring systems or monitoring devices to be installed such that representative measurements of emissions or process parameters (i.e., oxygen, or carbon dioxide) from the affected facility are obtained. Additional guidance for location of continuous monitoring systems to obtain representative samples are contained in the applicable Performance Specifications of appendix B of part 60 of this chapter.

3.6 Combined effluents. When the effluents from two or more affected facilities of similar design and operating characteristics are combined before being released to the atmosphere, the State plan may allow monitoring

systems to be installed on the combined effluent. When the affected facilities are not of similar design and operating characteristics, or when the effluent from one affected facility is released to the atmosphere through more than one point, the State should establish alternate procedures to implement the intent of these requirements.

3.7 Zero and drift. State plans shall require owners or operators of all continuous monitoring systems installed in accordance with the requirements of this appendix to record the zero and span drift in accordance with the method prescribed by the manufacturer of such instruments; to subject the instruments to the manufacturer's recommended zero and span check at least once daily unless the manufacturer has recommended adjustments at shorter intervals, in which case such recommendations shall be followed; to adjust the zero and span whenever the 24-hour zero drift or 24-hour calibration drift limits of the applicable performance specifications in appendix B of part 60 are exceeded; and to adjust continuous monitoring systems referenced by paragraph 3.2 of this appendix whenever the 24-hour zero drift or 24-hour calibration drift exceed 10 percent of the emission standard.

3.8 Span. Instrument span should be approximately 200 per cent of the expected instrument data display output corresponding to the emission standard for the source.

3.9 Alternative procedures and requirements. In cases where States wish to utilize different, but equivalent, procedures and requirements for continuous monitoring systems, the State plan must provide a description of such alternative procedures for approval by the Administrator. Some examples of situations that may require alternatives follow:

3.9.1 Alternative monitoring requirements to accommodate continuous monitoring systems that require corrections for stack moisture conditions (e.g., an instrument measuring steam generator SO₂ emissions on a wet basis could be used with an instrument measuring oxygen concentration on a dry basis if acceptable methods of measuring stack moisture conditions are used to allow accurate adjustments of the measured SO₂ concentration to dry basis.)

3.9.2 Alternative locations for installing continuous monitoring systems or monitoring devices when the owner or operator can demonstrate that installation at alternative locations will enable accurate and representative measurements.

3.9.3 Alternative procedures for performing calibration checks (e.g., some instruments may demonstrate superior drift characteristics that require checking at less frequent intervals).

3.9.4 Alternative monitoring requirements when the effluent from one affected facility or the combined effluent from two or more

identical affected facilities is released to the atmosphere through more than one point (e.g., an extractive, gaseous monitoring system used at several points may be approved if the procedures recommended are suitable for generating accurate emission averages).

3.9.5 Alternative continuous monitoring systems that do not meet the spectral response requirements in Performance Specification 1, appendix B of part 60, but adequately demonstrate a definite and consistent relationship between their measurements and the opacity measurements of a system complying with the requirements in Performance Specification 1. The State may require that such demonstration be performed for each affected facility.

4.0 Minimum data requirements. The following paragraphs set forth the minimum data reporting requirements necessary to comply with §51.214(d) and (e).

4.1 The State plan shall require owners or operators of facilities required to install continuous monitoring systems to submit a written report of excess emissions for each calendar quarter and the nature and cause of the excess emissions, if known. The averaging period used for data reporting should be established by the State to correspond to the averaging period specified in the emission test method used to determine compliance with an emission standard for the pollutant/source category in question. The required report shall include, as a minimum, the data stipulated in this appendix.

4.2 For opacity measurements, the summary shall consist of the magnitude in actual percent opacity of all one-minute (or such other time period deemed appropriate by the State) averages of opacity greater than the opacity standard in the applicable plan for each hour of operation of the facility. Average values may be obtained by integration over the averaging period or by arithmetically averaging a minimum of four equally spaced, instantaneous opacity measurements per minute. Any time period exempted shall be considered before determining the excess averages of opacity (e.g., whenever a regulation allows two minutes of opacity measurements in excess of the standard, the State shall require the source to report all opacity averages, in any one hour, in excess of the standard, minus the two-minute exemption). If more than one opacity standard applies, excess emissions data must be submitted in relation to all such standards.

4.3 For gaseous measurements the summary shall consist of emission averages, in the units of the applicable standard, for each averaging period during which the applicable standard was exceeded.

4.4 The date and time identifying each period during which the continuous monitoring system was inoperative, except for zero and

span checks, and the nature of system repairs or adjustments shall be reported. The State may require proof of continuous monitoring system performance whenever system repairs or adjustments have been made.

4.5 When no excess emissions have occurred and the continuous monitoring system(s) have not been inoperative, repaired, or adjusted, such information shall be included in the report.

4.6 The State plan shall require owners or operators of affected facilities to maintain a file of all information reported in the quarterly summaries, and all other data collected either by the continuous monitoring system or as necessary to convert monitoring data to the units of the applicable standard for a minimum of two years from the date of collection of such data or submission of such summaries.

5.0 *Data Reduction.* The State plan shall require owners or operators of affected facilities to use the following procedures for converting monitoring data to units of the standard where necessary.

5.1 For fossil fuel-fired steam generators the following procedures shall be used to convert gaseous emission monitoring data in parts per million to g/million cal (lb/million BTU) where necessary:

5.1.1 When the owner or operator of a fossil fuel-fired steam generator elects under paragraph 2.1.4 of this appendix to measure oxygen in the flue gases, the measurements of the pollutant concentration and oxygen concentration shall each be on a dry basis and the following conversion procedure used:

$$E = CF [20.9/20.9 - \%O_2]$$

5.1.2 When the owner or operator elects under paragraph 2.1.4 of this appendix to measure carbon dioxide in the flue gases, the measurement of the pollutant concentration and the carbon dioxide concentration shall each be on a consistent basis (wet or dry) and the following conversion procedure used:

$$E = CF_c (100 / \%CO_2)$$

5.1.3 The values used in the equations under paragraph 5.1 are derived as follows:

E = pollutant emission, g/million cal (lb/million BTU),

C = pollutant concentration, g/dscm (lb/dscf), determined by multiplying the average concentration (ppm) for each hourly period by 4.16×10^{-5} M g/dscm per ppm (2.64×10^{-9} M lb/dscf per ppm) where M = pollutant molecular weight, g/g-mole (lb/lb-mole). M = 64 for sulfur dioxide and 46 for oxides of nitrogen.

$\%O_2$, $\%CO_2$ = Oxygen or carbon dioxide volume (expressed as percent) determined with equipment specified under paragraph 4.1.4 of this appendix.

F, F_c = a factor representing a ratio of the volume of dry flue gases generated to the

calorific value of the fuel combusted (F), and a factor representing a ratio of the volume of carbon dioxide generated to the calorific value of the fuel combusted (F_c) respectively. Values of F and F_c are given in §60.45(f) of part 60, as applicable.

5.2 For sulfuric acid plants the owner or operator shall:

5.2.1 establish a conversion factor three times daily according to the procedures to §60.84(b) of this chapter;

5.2.2 multiply the conversion factor by the average sulfur dioxide concentration in the flue gases to obtain average sulfur dioxide emissions in Kg/metric ton (lb/short ton); and

5.2.3 report the average sulfur dioxide emission for each averaging period in excess of the applicable emission standard in the quarterly summary.

5.3 For nitric acid plants the owner or operator shall:

5.3.1 establish a conversion factor according to the procedures of §60.73(b) of this chapter;

5.3.2 multiply the conversion factor by the average nitrogen oxides concentration in the flue gases to obtain the nitrogen oxides emissions in the units of the applicable standard;

5.3.3 report the average nitrogen oxides emission for each averaging period in excess of the applicable emission standard, in the quarterly summary.

5.4 Any State may allow data reporting or reduction procedures varying from those set forth in this appendix if the owner or operator of a source shows to the satisfaction of the State that his procedures are at least as accurate as those in this appendix. Such procedures may include but are not limited to, the following:

5.4.1 Alternative procedures for computing emission averages that do not require integration of data (e.g., some facilities may demonstrate that the variability of their emissions is sufficiently small to allow accurate reduction of data based upon computing averages from equally spaced data points over the averaging period).

5.4.2 Alternative methods of converting pollutant concentration measurements to the units of the emission standards.

6.0 *Special Consideration.* The State plan may provide for approval, on a case-by-case basis, of alternative monitoring requirements different from the provisions of parts 1 through 5 of this appendix if the provisions of this appendix (i.e., the installation of a continuous emission monitoring system) cannot be implemented by a source due to physical plant limitations or extreme economic reasons. To make use of this provision, States must include in their plan specific criteria for determining those physical limitations or extreme economic situations

to be considered by the State. In such cases, when the State exempts any source subject to this appendix by use of this provision from installing continuous emission monitoring systems, the State shall set forth alternative emission monitoring and reporting requirements (e.g., periodic manual stack tests) to satisfy the intent of these regulations. Examples of such special cases include, but are not limited to, the following:

6.1 Alternative monitoring requirements may be prescribed when installation of a continuous monitoring system or monitoring device specified by this appendix would not provide accurate determinations of emissions (e.g., condensed, uncombined water vapor may prevent an accurate determination of opacity using commercially available continuous monitoring systems).

6.2 Alternative monitoring requirements may be prescribed when the affected facility is infrequently operated (e.g., some affected facilities may operate less than one month per year).

6.3 Alternative monitoring requirements may be prescribed when the State determines that the requirements of this appendix would impose an extreme economic burden on the source owner or operator.

6.4 Alternative monitoring requirements may be prescribed when the State determines that monitoring systems prescribed by this appendix cannot be installed due to physical limitations at the facility.

[40 FR 46247, Oct. 6, 1975, as amended at 51 FR 40675, Nov. 7, 1986]

APPENDIXES Q-R [RESERVED]

APPENDIX S TO PART 51—EMISSION OFFSET INTERPRETATIVE RULING

I. INTRODUCTION

This appendix sets forth EPA's Interpretative Ruling on the preconstruction review requirements for stationary sources of air pollution (not including indirect sources) under 40 CFR subpart I and section 129 of the Clean Air Act Amendments of 1977, Public Law 95-95, (note under 42 U.S.C. 7502). A major new source or major modification which would locate in an area designated in 40 CFR 81.300 *et seq.*, as nonattainment for a pollutant for which the source or modification would be major may be allowed to construct only if the stringent conditions set forth below are met. These conditions are designed to insure that the new source's emissions will be controlled to the greatest degree possible; that more than equivalent offsetting emission reductions (*emission offsets*) will be obtained from existing sources; and that there will be progress toward achievement of the NAAQS.

For each area designated as exceeding an NAAQS (nonattainment area) under 40 CFR 81.300 *et seq.*, this Interpretative Ruling will

be superseded after June 30, 1979—(a) by preconstruction review provisions of the revised SIP, if the SIP meets the requirements of Part D, Title 1, of the Act; or (b) by a prohibition on construction under the applicable SIP and section 110(a)(2)(I) of the Act, if the SIP does not meet the requirements of Part D. The Ruling will remain in effect to the extent not superseded under the Act. This prohibition on major new source construction does not apply to a source whose permit to construct was applied for during a period when the SIP was in compliance with Part D, or before the deadline for having a revised SIP in effect that satisfies Part D.

The requirement of this Ruling shall not apply to any major stationary source or major modification that was not subject to the Ruling as in effect on January 16, 1979, if the owner or operator:

A. Obtained all final Federal, State, and local preconstruction approvals or permits necessary under the applicable State Implementation Plan before August 7, 1980;

B. Commenced construction within 18 months from August 7, 1980, or any earlier time required under the applicable State Implementation Plan; and

C. Did not discontinue construction for a period of 18 months or more and completed construction within a reasonable time.

II. INITIAL SCREENING ANALYSES AND DETERMINATION OF APPLICABLE REQUIREMENTS

A. *Definitions*— For the purposes of this Ruling:

1. *Stationary source* means any building, structure, facility, or installation which emits or may emit any air pollutant subject to regulation under the Act.

2. *Building, structure, facility or installation* means all of the pollutant-emitting activities which belong to the same industrial grouping, are located on one or more contiguous or adjacent properties, and are under the control of the same person (or persons under common control) except the activities of any vessel. Pollutant-emitting activities shall be considered as part of the same industrial grouping if they belong to the same "Major Group" (i.e., which have the same two digit code) as described in the *Standard Industrial Classification Manual*, 1972, as amended by the 1977 Supplement (U.S. Government Printing Office stock numbers 4101-0066 and 003-005-00176-0, respectively).

3. *Potential to emit* means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design only if the limitation or

the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source.

4. (i) *Major stationary source* means:

(a) Any stationary source of air pollutants which emits, or has the potential to emit, 100 tons per year or more of any pollutant subject to regulation under the Act; or

(b) Any physical change that would occur at a stationary source not qualifying under paragraph 5.(i)(a) of section II of this appendix as a major stationary source, if the change would constitute a major stationary source by itself.

(ii) A major stationary source that is major for volatile organic compounds shall be considered major for ozone.

(iii) The fugitive emissions of a stationary source shall not be included in determining for any of the purposes of this ruling whether it is a major stationary source, unless the source belongs to one of the following categories of stationary sources:

(a) Coal cleaning plants (with thermal dryers);

(b) Kraft pulp mills;

(c) Portland cement plants;

(d) Primary zinc smelters;

(e) Iron and steel mills;

(f) Primary aluminum ore reduction plants;

(g) Primary copper smelters;

(h) Municipal incinerators capable of charging more than 250 tons of refuse per day;

(i) Hydrofluoric, sulfuric, or nitric acid plants;

(j) Petroleum refineries;

(k) Lime plants;

(l) Phosphate rock processing plants;

(m) Coke oven batteries;

(n) Sulfur recovery plants;

(o) Carbon black plants (furnace process);

(p) Primary lead smelters;

(q) Fuel conversion plants;

(r) Sintering plants;

(s) Secondary metal production plants;

(t) Chemical process plants;

(u) Fossil-fuel boilers (or combination thereof) totaling more than 250 million British thermal units per hour heat input;

(v) Petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels;

(w) Taconite ore processing plants;

(x) Glass fiber processing plants;

(y) Charcoal production plants;

(z) Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;

(aa) Any other stationary source category which, as of August 7, 1980, is being regulated under section 111 or 112 of the Act.

5. (i) *Major modification* means any physical change in or change in the method of operation of a major stationary source that

would result in a significant net emissions increase of any pollutant subject to regulation under the Act.

(ii) Any net emissions increase that is considered significant for volatile organic compounds shall be considered significant for ozone.

(iii) A physical change or change in the method of operation shall not include:

(a) Routine maintenance, repair, and replacement;

(b) Use of an alternative fuel or raw material by reason of an order under section 2 (a) and (b) of the Energy Supply and Environmental Coordination Act of 1974 (or any superseding legislation) or by reason of a natural gas curtailment plan pursuant to the Federal Power Act;

(c) Use of an alternative fuel by reason of an order or rule under section 125 of the Act;

(d) Use of an alternative fuel at a steam generating unit to the extent that the fuel is generated from municipal solid waste;

(e) Use of an alternative fuel or raw material by a stationary source which:

(f) The source was capable of accommodating before December 21, 1976, unless such change would be prohibited under any federally enforceable permit condition which was established after December 21, 1976, pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR subpart I or § 51.166; or

(g) The source is approved to use under any permit issued under this ruling;

(f) An increase in the hours of operation or in the production rate, unless such change is prohibited under any federally enforceable permit condition which was established after December 21, 1976 pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR subpart I or § 51.166;

(g) Any change in ownership at a stationary source.

6. (i) *Net emissions increase* means the amount by which the sum of the following exceeds zero:

(a) Any increase in actual emissions from a particular physical change or change in the method of operation at a stationary source; and

(b) Any other increases and decreases in actual emissions at the source that are contemporaneous with the particular change and are otherwise creditable.

(ii) An increase or decrease in actual emissions is contemporaneous with the increase from the particular change only if it occurs between:

(a) The date five years before construction on the particular change commences and

(b) The date that the increase from the particular change occurs.

(iii) An increase or decrease in actual emissions is creditable only if the Administrator has not relied on it in issuing a permit

for the source under this Ruling which permit is in effect when the increase in actual emissions from the particular change occurs.

(iv) An increase in actual emissions is creditable only to the extent that the new level of actual emissions exceeds the old level.

(v) A decrease in actual emissions is creditable only to the extent that:

(a) The old level of actual emissions or the old level of allowable emissions, whichever is lower, exceeds the new level of actual emissions;

(b) It is federally enforceable at and after the time that actual construction on the particular change begins;

(c) The reviewing authority has not relied on it in issuing any permit under regulations approved pursuant to 40 CFR 51.18; and

(d) It has approximately the same qualitative significance for public health and welfare as that attributed to the increase from the particular change.

(vi) An increase that results from a physical change at a source occurs when the emissions unit on which construction occurred becomes operational and begins to emit a particular pollutant. Any replacement unit that requires shakedown becomes operational only after a reasonable shakedown period, not to exceed 180 days.

7. *Emissions unit* means any part of a stationary source which emits or would have the potential to emit any pollutant subject to regulation under the Act.

8. *Secondary emissions* means emissions which would occur as a result of the construction or operation of a major stationary source or major modification, but do not come from the major stationary source or major modification itself. For the purpose of this Ruling, secondary emissions must be specific, well defined, quantifiable, and impact the same general area as the stationary source or modification which causes the secondary emissions. Secondary emissions include emissions from any offsite support facility which would not be constructed or increase its emissions except as a result of the construction or operation of the major stationary source or major modification. Secondary emissions do not include any emissions which come directly from a mobile source, such as emissions from the tailpipe of a motor vehicle, from a train, or from a vessel.

9. *Fugitive emissions* means those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

10. (i) *Significant* means, in reference to a net emissions increase or the potential of a source to emit any of the following pollutants, a rate of emissions that would equal or exceed any of the following rates:

Pollutant and Emissions Rate

Carbon monoxide: 100 tons per year (tpy)

Nitrogen oxides: 40 tpy

Sulfur dioxide: 40 tpy

Particulate matter: 25 tpy of particulate matter emissions

Ozone: 40 tpy of volatile organic compounds

Lead: 0.6 tpy

11. *Allowable emissions* means the emissions rate calculated using the maximum rated capacity of the source (unless the source is subject to federally enforceable limits which restrict the operating rate, or hours of operation, or both) and the most stringent of the following:

(i) Applicable standards as set forth in 40 CFR parts 60 and 61;

(ii) Any applicable State Implementation Plan emissions limitation, including those with a future compliance date; or

(iii) The emissions rate specified as a federally enforceable permit condition, including those with a future compliance date.

12. *Federally enforceable* means all limitations and conditions which are enforceable by the Administrator, including those requirements developed pursuant to 40 CFR parts 60 and 61, requirements within any applicable State implementation plan, any permit requirements established pursuant to 40 CFR 52.21 or under regulations approved pursuant to 40 CFR part 51, subpart I, including operating permits issued under an EPA-approved program that is incorporated into the State implementation plan and expressly requires adherence to any permit issued under such program.

13. (i) *Actual emissions* means the actual rate of emissions of a pollutant from an emissions unit as determined in accordance with paragraphs 16. (ii) through (iv) of Section II.A. of this appendix.

(ii) In general, actual emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a two-year period which precedes the particular date and which is representative of normal source operation. The reviewing authority shall allow the use of a different time period upon a determination that it is more representative of normal source operation. Actual emissions shall be calculated using the unit's actual operating hours, production rates, and types of materials processed, stored or combusted during the selected time period.

(iii) The reviewing authority may presume that source-specific allowable emissions for the unit are equivalent to the actual emissions of the unit.

(iv) For any emissions unit which has not begun normal operations on the particular date, actual emissions shall equal the potential to emit of the unit on that date.

14. *Construction* means any physical change or change in the method of operation (including fabrication, erection, installation, demolition, or modification of an emissions unit) which would result in a change in actual emissions.

15. *Commence* as applied to construction of a major stationary source or major modification means that the owner or operator has all necessary preconstruction approvals or permits and either has:

(i) Begun, or caused to begin, a continuous program of actual on-site construction of the source, to be completed within a reasonable time; or

(ii) Entered into binding agreements or contractual obligations, which cannot be cancelled or modified without substantial loss to the owner or operator, to undertake a program of actual construction of the source to be completed within a reasonable time.

16. *Necessary preconstruction approvals or permits* means those permits or approvals required under Federal air quality control laws and regulations and those air quality control laws and regulations which are part of the applicable State Implementation Plan.

17. *Begin actual construction* means, in general, initiation of physical on-site construction activities on an emissions unit which are of a permanent nature. Such activities include, but are not limited to, installation of building supports and foundations, laying of underground pipework, and construction of permanent storage structures. With respect to a change in method of operating this term refers to those on-site activities other than preparatory activities which mark the initiation of the change.

18. *Lowest achievable emission rate* means, for any source, the more stringent rate of emissions based on the following:

(i) The most stringent emissions limitation which is contained in the implementation plan of any State for such class or category of stationary source, unless the owner or operator of the proposed stationary source demonstrates that such limitations are not achievable; or

(ii) The most stringent emissions limitation which is achieved in practice by such class or category of stationary source. This limitation, when applied to a modification, means the lowest achievable emissions rate for the new or modified emissions units within the stationary source. In no event shall the application of this term permit a proposed new or modified stationary source to emit any pollutant in excess of the amount allowable under applicable new source standards of performance.

19. *Resource recovery facility* means any facility at which solid waste is processed for the purpose of extracting, converting to energy, or otherwise separating and preparing solid waste for reuse. Energy conversion facilities must utilize solid waste to provide

more than 50 percent of the heat input to be considered a resource recovery facility under this Ruling.

20. *Volatile organic compounds (VOC)* is as defined in §51.100(s) of this part.

B. *Review of all sources for emission limitation compliance.* The reviewing authority must examine each proposed major new source and proposed major modification¹ to determine if such a source will meet all applicable emission requirements in the SIP, any applicable new source performance standard in 40 CFR part 60, or any national emission standard for hazardous air pollutants in 40 CFR part 61. If the reviewing authority determines that the proposed major new source cannot meet the applicable emission requirements, the permit to construct must be denied.

C. *Review of specified sources for air quality impact.* In addition, the reviewing authority must determine whether the major stationary source or major modification would be constructed in an area designated in 40 CFR 81.300 *et seq.* as nonattainment for a pollutant for which the stationary source or modification is major.

D.-E. [Reserved]

F. *Fugitive emissions sources.* Section IV. A. of this Ruling shall not apply to a source or modification that would be a major stationary source or major modification only if fugitive emissions, to the extent quantifiable, are considered in calculating the potential to emit of the stationary source or modification and the source does not belong to any of the following categories:

- (1) Coal cleaning plants (with thermal dryers);
- (2) Kraft pulp mills;
- (3) Portland cement plants;
- (4) Primary zinc smelters;
- (5) Iron and steel mills;
- (6) Primary aluminum ore reduction plants;
- (7) Primary copper smelters;
- (8) Municipal incinerators capable of charging more than 250 tons of refuse per day;
- (9) Hydrofluoric, sulfuric, or nitric acid plants;
- (10) Petroleum refineries;
- (11) Lime plants;
- (12) Phosphate rock processing plants;
- (13) Coke oven batteries;
- (14) Sulfur recovery plants;
- (15) Carbon black plants (furnace process);
- (16) Primary lead smelters;
- (17) Fuel conversion plants;
- (18) Sintering plants;
- (19) Secondary metal production plants;
- (20) Chemical process plants;

¹Hereafter the term *source* will be used to denote both any source and any modification.

(21) Fossil-fuel boilers (or combination thereof) totaling more than 250 million British thermal units per hour heat input;

(22) Petroleum storage and transfer units with a total storage capacity exceeding 300,000 barrels;

(23) Taconite ore processing plants;

(24) Glass fiber processing plants;

(25) Charcoal production plants;

(26) Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input;

(27) Any other stationary source category which, as of August 7, 1980, is being regulated under section 111 or 112 of the Act.

G. *Secondary emissions.* Secondary emissions need not be considered in determining whether the emission rates in Section II.C. above would be exceeded. However, if a source is subject to this Ruling on the basis of the direct emissions from the source, the applicable conditions of this Ruling must also be met for secondary emissions. However, secondary emissions may be exempt

from Conditions 1 and 2 of Section IV. Also, since EPA's authority to perform or require indirect source review relating to mobile sources regulated under Title II of the Act (motor vehicles and aircraft) has been restricted by statute, consideration of the indirect impacts of motor vehicles and aircraft traffic is not required under this Ruling.

III. SOURCES LOCATING IN DESIGNATED CLEAN OR UNCLASSIFIABLE AREAS WHICH WOULD CAUSE OR CONTRIBUTE TO A VIOLATION OF A NATIONAL AMBIENT AIR QUALITY STANDARD

A. This section applies only to major sources or major modifications which would locate in an area designated in 40 CFR 81.300 *et seq.* as attainment or unclassifiable in a State where EPA has not yet approved the State preconstruction review program required by 40 CFR 51.165(b), if the source or modification would exceed the following significance levels at any locality that does not meet the NAAQS:

Pollutant	Annual	Averaging time (hours)			
		24	8	3	1
SO ₂	1.0 µg/m ³	5 µg/m ³ .....	.....	25 µg/m ³	
TSP	1.0 µg/m ³	5 µg/m ³ .....	.....	.....
NO ₂	1.0 µg/m ³ .....	.....	.....	.....
CO .....	.....	.....	0.5 mg/m ³ .....	.....	2 mg/m ³ .

B. Sources to which this section applies must meet Conditions 1, 2, and 4 of Section IV.A. of this ruling.² However, such sources may be exempt from Condition 3 of Section IV.A. of this ruling.

C. *Review of specified sources for air quality impact.* For stable air pollutants (i.e. SO₂, particulate matter and CO), the determination of whether a source will cause or contribute to a violation of an NAAQS generally should be made on a case-by-case basis as of the proposed new source's start-up date using the source's allowable emissions in an atmospheric simulation model (unless a source will clearly impact on a receptor which exceeds an NAAQS).

For sources of nitrogen oxides, the initial determination of whether a source would cause or contribute to a violation of the NAAQS for NO₂ should be made using an atmospheric simulation model assuming all the nitric oxide emitted is oxidized to NO₂ by the time the plume reaches ground level. The initial concentration estimates may be adjusted if adequate data are available to account for the expected oxidation rate.

For ozone, sources of volatile organic compounds, locating outside a designated ozone

nonattainment area, will be presumed to have no significant impact on the designated nonattainment area. If ambient monitoring indicates that the area of source location is in fact nonattainment, then the source may be permitted under the provisions of any State plan adopted pursuant to section 110(a)(2)(D) of the Act until the area is designated nonattainment and a State Implementation Plan revision is approved. If no State plan pursuant to section 110(a)(2)(D) has been adopted and approved, then this Ruling shall apply.

As noted above, the determination as to whether a source would cause or contribute to a violation of an NAAQS should be made as of the new source's start-up date. Therefore, if a designated nonattainment area is projected to be an attainment area as part of an approved SIP control strategy by the new source start-up date, offsets would not be required if the new source would not cause a new violation.

D. *Sources locating in clean areas,* but would cause a new violating of an NAAQS. If the reviewing authority finds that the emissions from a proposed source would cause a new violation of an NAAQS, but would not contribute to an existing violation, approval may be granted only if both of the following conditions are met:

²The discussion in this paragraph is a proposal, but represents EPA's interim policy until final rulemaking is completed.

Condition 1. The new source is required to meet a more stringent emission limitation³ and/or the control of existing sources below allowable levels is required so that the source will not cause a violation of any NAAQS.

Condition 2. The new emission limitations for the new source as well as any existing sources affected must be enforceable in accordance with the mechanisms set forth in Section V of this appendix.

IV. SOURCES THAT WOULD LOCATE IN A DESIGNATED NONATTAINMENT AREA

A. *Conditions for approval.* If the reviewing authority finds that the major stationary source or major modification would be constructed in an area designated in 40 CFR 81.300 *et seq* as nonattainment for a pollutant for which the stationary source or modification is major, approval may be granted only if the following conditions are met:

Condition 1. The new source is required to meet an emission Limitation⁴ which speci-

fies the lowest achievable emission rate for such source.⁵

Condition 2. The applicant must certify that all existing major sources owned or operated by the applicant (or any entity controlling, controlled by, or under common control with the applicant) in the same State as the proposed source are in compliance with all applicable emission limitations and standards under the Act (or are in compliance with an expeditious schedule which is Federally enforceable or contained in a court decree).

Condition 3. Emission reductions (*offsets*) from existing sources⁶ in the area of the proposed source (whether or not under the same ownership) are required such that there will be reasonable progress toward attainment of the applicable NAAQs.⁷

Only intrapollutant emission offsets will be acceptable (e.g., hydrocarbon increases may not be offset against SO₂ reductions).

Condition 4. The emission offsets will provide a positive net air quality benefit in the affected area (see Section IV.D. below).⁸ Atmospheric simulation modeling is not necessary for volatile organic compounds and NO_x. Fulfillment of Condition 3 and Section

³If the reviewing authority determines that technological or economic limitations on the application of measurement methodology to a particular class of sources would make the imposition of an enforceable numerical emission standard infeasible, the authority may instead prescribe a design, operational or equipment standard. In such cases, the reviewing authority shall make its best estimate as to the emission rate that will be achieved and must specify that rate in the required submission to EPA (see Part V). Any permits issued without an enforceable numerical emission standard must contain enforceable conditions which assure that the design characteristics or equipment will be properly maintained (or that the operational conditions will be properly performed) so as to continuously achieve the assumed degree of control. Such conditions shall be enforceable as emission limitations by private parties under section 304. Hereafter, the term *emission limitation* shall also include such design, operational, or equipment standards.

⁴If the reviewing authority determines that technological or economic limitations on the application of measurement methodology to a particular class of sources would make the imposition of an enforceable numerical emission standard infeasible, the authority may instead prescribe a design, operational or equipment standard. In such cases, the reviewing authority shall make its best estimate as to the emission rate that will be achieved and must specify that rate in the required submission to EPA (see Part V). Any permits issued without an enforceable numerical emission standard must contain enforceable conditions which assure that the design characteristics or equipment

will be properly maintained (or that the operational conditions will be properly performed) so as to continuously achieve the assumed degree of control. Such conditions shall be enforceable as emission limitations by private parties under section 304. Hereafter, the term *emission limitation* shall also include such design, operational, or equipment standards.

⁵Required only for those pollutants for which the increased allowable emissions exceed 50 tons per year, 1000 pounds per day, or 100 pounds per hour, although the reviewing authority may address other pollutants if deemed appropriate. The preceding hourly and daily rates shall apply only with respect to a pollutant for which a national ambient air quality standard, for a period less than 24 hours or for a 24-hour period, as appropriate, has been established.

⁶Subject to the provisions of section IV.C. below.

⁷The discussion in this paragraph is a proposal, but represents EPA's interim policy until final rulemaking is completed.

⁸Required only for those pollutants for which the increased allowable emissions exceed 50 tons per year, 1000 pounds per day, or 100 pounds per hour, although the reviewing authority may address other pollutants if deemed appropriate. The preceding hourly and daily rates shall apply only with respect to a pollutant for which a national ambient air quality standard, for a period less than 24 hours or for a 24-hour period, as appropriate, has been established.

IV.D. will be considered adequate to meet this condition.

B. *Exemptions from certain conditions.* The reviewing authority may exempt the following sources from Condition 1 under Section III or Conditions 3 and 4. Section IV.A.:

(i) Resource recovery facilities burning municipal solid waste, and (ii) sources which must switch fuels due to lack of adequate fuel supplies or where a source is required to be modified as a result of EPA regulations (e.g., lead-in-fuel requirements) and no exemption from such regulation is available to the source. Such an exemption may be granted only if:

1. The applicant demonstrates that it made its best efforts to obtain sufficient emission offsets to comply with Condition 1 under Section III or Conditions 3 and 4 under Section IV.A. and that such efforts were unsuccessful;

2. The applicant has secured all available emission offsets; and

3. The applicant will continue to seek the necessary emission offsets and apply them when they become available.

Such an exemption may result in the need to revise the SIP to provide additional control of existing sources.

Temporary emission sources, such as pilot plants, portable facilities which will be relocated outside of the nonattainment area after a short period of time, and emissions resulting from the construction phase of a new source, are exempt from Conditions 3 and 4 of this section.

C. *Baseline for determining credit for emission and air quality offsets.* The baseline for determining credit for emission and air quality offsets will be the SIP emission limitations in effect at the time the application to construct or modify a source is filed. Thus, credit for emission offset purposes may be allowable for existing control that goes beyond that required by the SIP. Emission offsets generally should be made on a pounds per hour basis when all facilities involved in the emission offset calculations are operating at their maximum expected or allowed production rate. The reviewing agency should specify other averaging periods (e.g., tons per year) in addition to the pounds per hour basis if necessary to carry out the intent of this Ruling. When offsets are calculated on a tons per year basis, the baseline emissions for existing sources providing the offsets should be calculated using the actual annual operating hours for the previous one or two year period (or other appropriate period if warranted by cyclical business conditions). Where the SIP requires certain hardware controls in lieu of an emission limitation (e.g., floating roof tanks for petroleum storage), baseline allowable emissions should be based on actual operating conditions for the previous one or two year period (i.e., actual

throughput and vapor pressures) in conjunction with the required hardware controls.

1. *No meaningful or applicable SIP requirement.* Where the applicable SIP does not contain an emission limitation for a source or source category, the emission offset baseline involving such sources shall be the actual emissions determined in accordance with the discussion above regarding operating conditions.

Where the SIP emission limit allows greater emissions than the uncontrolled emission rate of the source (as when a State has a single particulate emission limit for all fuels), emission offset credit will be allowed only for control below the uncontrolled emission rate.

2. *Combustion of fuels.* Generally, the emissions for determining emission offset credit involving an existing fuel combustion source will be the allowable emissions under the SIP for the type of fuel being burned at the time the new source application is filed (i.e., if the existing source has switched to a different type of fuel at some earlier date, any resulting emission reduction [either actual or allowable] shall not be used for emission offset credit). If the existing source commits to switch to a cleaner fuel at some future date, emission offset credit based on the allowable emissions for the fuels involved is not acceptable unless the permit is conditioned to require the use of a specified alternative control measure which would achieve the same degree of emission reduction should the source switch back to a dirtier fuel at some later date. The reviewing authority should ensure that adequate long-term supplies of the new fuel are available before granting emission offset credit for fuel switches.

3. (i) *Operating hours and source shutdown.*

A source may generally be credited with emissions reductions achieved by shutting down an existing source or permanently curtailing production or operating hours below baseline levels (see initial discussion in this Section IV.C), if such reductions are permanent, quantifiable, and federally enforceable, and if the area has an EPA-approved attainment plan. In addition, the shutdown or curtailment is creditable only if it occurred on or after the date specified for this purpose in the plan, and if such date is on or after the date of the most recent emissions inventory used in the plan's demonstration of attainment. Where the plan does not specify a cut-off date for shutdown credits, the date of the most recent emissions inventory or attainment demonstration, as the case may be, shall apply. However, in no event may credit be given for shutdowns which occurred prior to August 7, 1977. For purposes of this paragraph, a permitting authority may choose to consider a prior shutdown or curtailment to have occurred after the date of its most recent emissions inventory, if the inventory

explicitly includes as current "existing" emissions the emissions from such previously shutdown or curtailed sources.

(ii) Such reductions may be credited in the absence of an approved attainment demonstration only if the shutdown or curtailment occurred on or after the date the new source application is filed, or, if the applicant can establish that the proposed new source is a replacement for the shutdown or curtailed source and the cutoff date provisions of section IV.C.3.(i) are observed.

4. *Credit for VOC substitution.* As set forth in the Agency's "Recommended Policy on Control of Volatile Organic Compounds" (42 FR 35314, July 8, 1977), EPA has found that almost all non-methane VOCs are photochemically reactive and that low reactivity VOCs eventually form as much ozone as the highly reactive VOCs. Therefore, no emission offset credit may be allowed for replacing one VOC compound with another of lesser reactivity, except for those compounds listed in Table 1 of the above policy statement.

5. *"Banking" of emission offset credit.* For new sources obtaining permits by applying offsets after January 16, 1979, the reviewing authority may allow offsets that exceed the requirements of reasonable progress toward attainment (Condition 3) to be "banked" (i.e., saved to provide offsets for a source seeking a permit in the future) for use under this Ruling. Likewise, the reviewing authority may allow the owner of an existing source that reduces its own emissions to bank any resulting reductions beyond those required by the SIP for use under this Ruling, even if none of the offsets are applied immediately to a new source permit. A reviewing authority may allow these banked offsets to be used under the preconstruction review program required by Part D, as long as these banked emissions are identified and accounted for in the SIP control strategy. A reviewing authority may not approve the construction of a source using banked offsets if the new source would interfere with the SIP control strategy or if such use would violate any other condition set forth for use of offsets. To preserve banked offsets, the reviewing authority should identify them in either a SIP revision or a permit, and establish rules as to how and when they may be used.

6. *Offset credit for meeting NSPS or NESHAPS.* Where a source is subject to an emission limitation established in a New Source Performance Standard (NSPS) or a National Emission Standard for Hazardous Air Pollutants (NESHAPS), (i.e., requirements under sections 111 and 112, respectively, of the Act), and a different SIP limitation, the more stringent limitation shall be used as the baseline for determining credit for emission and air quality offsets. The difference in emissions between the SIP and the NSPS or NESHAPS, for such source may

not be used as offset credit. However, if a source were not subject to an NSPS or NESHAPS, for example if its construction had commenced prior to the proposal of an NSPS or NESHAPS for that source category, offset credit can be permitted for tightening the SIP to the NSPS or NESHAPS level for such source.

D. *Location of offsetting emissions.* In the case of emission offsets involving volatile organic compounds (VOC), the offsets may be obtained from sources located anywhere in the broad vicinity of the proposed new source. Generally, offsets will be acceptable if obtained from within the same AQCR as the new source or from other areas which may be contributing to the ozone problem at the proposed new source location. As with other pollutants, it is desirable to obtain offsets from sources located as close to the proposed new source site as possible. If the proposed offsets would be from sources located at greater distances from the new source, the reviewing authority should increase the ratio of the required offsets and require a showing that nearby offsets were investigated and reasonable alternatives were not available.⁹

Offsets for NO_x sources may also be obtained within the broad vicinity of the proposed new source. This is because areawide ozone and NO₂ levels are generally not as dependent on specific VOC or NO_x source location as they are on overall area emissions. Since the air quality impact of SO₂, particulate and carbon monoxide sources is site dependent, simple areawide mass emission offsets are not appropriate. For these pollutants, the reviewing authority should consider atmospheric simulation modeling to ensure that the emission offsets provide a positive net air quality benefit. However, to avoid unnecessary consumption of limited, costly and time consuming modeling resources, in most cases it can be assumed that if the emission offsets are obtained from an existing source on the same premises or in the immediate vicinity of the new source, and the pollutants disperse from substantially the same effective stack height, the air quality test under Condition 4 of Section IV.A. of this appendix will be met. Thus, when stack emissions are offset against a ground level source at the same site, modeling would be required. The reviewing authority may perform this analysis or require the applicant to submit appropriate modeling results.

E. *Reasonable progress towards attainment.* As long as the emission offset is greater than one-for-one, and the other criteria set forth

⁹The discussion in this paragraph is a proposal, but represents EPA's interim policy until final rulemaking is completed.

above are met, EPA does not intend to question a reviewing authority's judgment as to what constitutes reasonable progress towards attainment as required under Condition 3 in Section IV.A. of this appendix. This does not apply to "reasonable further progress" as required by Section 173.

F. *Source obligation.* At such time that a particular source or modification becomes a major stationary source or major modification solely by virtue of a relaxation in any enforceable limitation which was established after August 7, 1980, on the capacity of the source or modification otherwise to emit a pollutant, such as a restriction on hours of operation, then the requirements of this Ruling shall apply to the source or modification as though construction had not yet commenced on the source or modification.

V. ADMINISTRATIVE PROCEDURES

The necessary emission offsets may be proposed either by the owner of the proposed source or by the local community or the State. The emission reduction committed to must be enforceable by authorized State and/or local agencies and under the Clean Air Act, and must be accomplished by the new source's start-up date. If emission reductions are to be obtained in a State that neighbors the State in which the new source is to be located, the emission reductions committed to must be enforceable by the neighboring State and/or local agencies and under the Clean Air Act. Where the new facility is a replacement for a facility that is being shut down in order to provide the necessary offsets, the reviewing authority may allow up to 180 days for shakedown of the new facility before the existing facility is required to cease operation.

A. *Source initiated emission offsets.* A source may propose emission offsets which involve:

(1) Reductions from sources controlled by the source owner (internal emission offsets); and/or (2) reductions from neighboring sources (external emission offsets). The source does not have to investigate all possible emission offsets. As long as the emission offsets obtained represent reasonable progress toward attainment, they will be acceptable. It is the reviewing authority's responsibility to assure that the emission offsets will be as effective as proposed by the source. An internal emission offset will be considered enforceable if it is made a SIP requirement by inclusion as a condition of the new source permit and the permit is forwarded to the appropriate EPA Regional Office.¹⁰ An external emission offset will not be

enforceable unless the affected source(s) providing the emission reductions is subject to a new SIP requirement to ensure that its emissions will be reduced by a specified amount in a specified time. Thus, if the source(s) providing the emission reductions does not obtain the necessary reduction, it will be in violation of a SIP requirement and subject to enforcement action by EPA, the State and/or private parties.

The form of the SIP revision may be a State or local regulation, operating permit condition, consent or enforcement order, or any other mechanism available to the State that is enforceable under the Clean Air Act. If a SIP revision is required, the public hearing on the revision may be substituted for the normal public comment procedure required for all major sources under 40 CFR 51.18. The formal publication of the SIP revision approval in the FEDERAL REGISTER need not appear before the source may proceed with construction. To minimize uncertainty that may be caused by these procedures, EPA will, if requested by the State, propose a SIP revision for public comment in the FEDERAL REGISTER concurrently with the State public hearing process. Of course, any major change in the final permit/SIP revision submitted by the State may require a reproposal by EPA.

B. *State or community initiated emission offsets.* A State or community which desires that a source locate in its area may commit to reducing emissions from existing sources (including mobile sources) to sufficiently outweigh the impact of the new source and thus open the way for the new source. As with source-initiated emission offsets, the commitment must be something more than one-for-one. This commitment must be submitted as a SIP revision by the State.

VI. POLICY WHERE ATTAINMENT DATES HAVE NOT PASSED

In some cases, the dates for attainment of primary standards specified in the SIP under section 110 have not yet passed due to a delay in the promulgation of a plan under this section of the Act. In addition the Act provides more flexibility with respect to the dates for attainment of secondary NAAQS than for primary standards. Rather than setting specific deadlines, section 110 requires secondary NAAQS to be achieved within a "reasonable time". Therefore, in some cases, the date for attainment of secondary standards specified in the SIP under section 110 may also not yet have passed. In such cases, a new source locating in an area designated in 40 CFR 81.3000 *et seq.* as nonattainment (or, where Section III of this Ruling is applicable, a new source which would cause or contribute to an NAAQS violation) may be exempt from the Conditions of Section IV. A.

¹⁰The emission offset will, therefore, be enforceable by EPA under section 113 as an applicable SIP requirement and will be enforceable by private parties under section 304 as an emission limitation.

so long as the new source meets the applicable SIP emissions limitations and will not interfere with the attainment date specified in the SIP under section 110 of the Act.

(Secs. 101(b)(1), 110, 160-169, 171-178, and 301(a), Clean Air Act, as amended (42 U.S.C. 7401(b)(1), 7410, 7470-7479, 7501-7508, and 7601(a)); sec. 129(a), Clean Air Act Amendments of 1977 (Pub. L. 95-95, 91 Stat. 685 (Aug., 7, 1977)))

[44 FR 3282, Jan. 16, 1979, as amended at 45 FR 31311, May 13, 1980; 45 FR 52741, Aug. 7, 1980; 45 FR 59879, Sept. 11, 1980; 46 FR 50771, Oct. 14, 1981; 47 FR 27561, June 25, 1982; 49 FR 43210, Oct. 26, 1984; 51 FR 40661, 40675, Nov. 7, 1986; 52 FR 24714, July 1, 1987; 52 FR 29386, Aug. 7, 1987; 54 FR 27285, 27299, June 28, 1989; 57 FR 3946, Feb. 3, 1992]

APPENDIXES T-U [RESERVED]

APPENDIX V TO PART 51—CRITERIA FOR DETERMINING THE COMPLETENESS OF PLAN SUBMISSIONS

1.0. PURPOSE

This appendix V sets forth the minimum criteria for determining whether a State implementation plan submitted for consideration by EPA is an official submission for purposes of review under § 51.103.

1.1 The EPA shall return to the submitting official any plan or revision thereof which fails to meet the criteria set forth in this appendix V, and request corrective action, identifying the component(s) absent or insufficient to perform a review of the submitted plan.

1.2 The EPA shall inform the submitting official whether or not a plan submission meets the requirements of this appendix V within 60 days of EPA's receipt of the submittal, but no later than 6 months after the date by which the State was required to submit the plan or revision. If a completeness determination is not made by 6 months from receipt of a submittal, the submittal shall be deemed complete by operation of law on the date 6 months from receipt. A determination of completeness under this paragraph means that the submission is an official submission for purposes of § 51.103.

2.0. CRITERIA

The following shall be included in plan submissions for review by EPA:

2.1. Administrative Materials

(a) A formal letter of submittal from the Governor or his designee, requesting EPA approval of the plan or revision thereof (hereafter "the plan").

(b) Evidence that the State has adopted the plan in the State code or body of regulations; or issued the permit, order, consent agreement (hereafter "document") in final

form. That evidence shall include the date of adoption or final issuance as well as the effective date of the plan, if different from the adoption/issuance date.

(c) Evidence that the State has the necessary legal authority under State law to adopt and implement the plan.

(d) A copy of the actual regulation, or document submitted for approval and incorporation by reference into the plan, including indication of the changes made to the existing approved plan, where applicable. The submittal shall be a copy of the official State regulation /document signed, stamped, dated by the appropriate State official indicating that it is fully enforceable by the State. The effective date of the regulation/document shall, whenever possible, be indicated in the document itself.

(e) Evidence that the State followed all of the procedural requirements of the State's laws and constitution in conducting and completing the adoption/issuance of the plan.

(f) Evidence that public notice was given of the proposed change consistent with procedures approved by EPA, including the date of publication of such notice.

(g) Certification that public hearings(s) were held in accordance with the information provided in the public notice and the State's laws and constitution, if applicable.

(h) Compilation of public comments and the State's response thereto.

2.2. Technical Support

(a) Identification of all regulated pollutants affected by the plan.

(b) Identification of the locations of affected sources including the EPA attainment/nonattainment designation of the locations and the status of the attainment plan for the affected areas(s).

(c) Quantification of the changes in plan allowable emissions from the affected sources; estimates of changes in current actual emissions from affected sources or, where appropriate, quantification of changes in actual emissions from affected sources through calculations of the differences between certain baseline levels and allowable emissions anticipated as a result of the revision.

(d) The State's demonstration that the national ambient air quality standards, prevention of significant deterioration increments, reasonable further progress demonstration, and visibility, as applicable, are protected if the plan is approved and implemented. For all requests to redesignate an area to attainment for a national primary ambient air quality standard, under section 107 of the Act, a revision must be submitted to provide for the maintenance of the national primary ambient air quality standards for at least 10 years as required by section 175A of the Act.

(e) Modeling information required to support the proposed revision, including input